POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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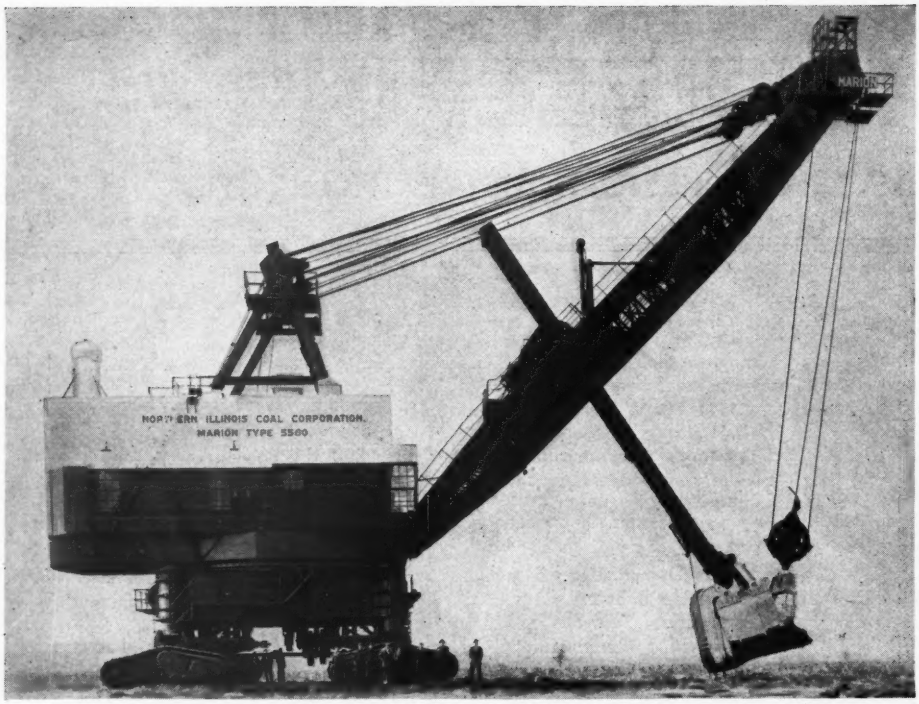


Electric shovel which handles 50 tons at one scoop. (Photo, General Electric)

Fifty Tons at One Scoop!

WITH THE ABILITY to pick up a 50 ton load and place it on top of an ordinary six or seven story office building, this power shovel has recently been placed in operation by the Northern Illinois Coal Corporation for use in coal stripping service. This giant, the world's largest, was built by the Marion Steam Shovel Co. of Marion, Ohio, and its electric drive and control equipment was furnished by the General Electric Co.

One of the outstanding features of the machine is its immense dipper, or bucket, which has a rated capacity of 32 cubic yards, or approximately 40 cubic yards heaped up,—enough to fill an ordinary room at one scoop. In coal stripping operations where it will be handling earth, shale and broken rock, the weight of one dipper load is approximately 50 tons! The dipper itself is fabricated from aluminum plates and castings with an armor of special wear-resisting steel at the points where the greatest wear is encountered. The dipper measures approximately 9⅔ by 8⅓ by 16⅓ feet.

Despite its great size and the amazing capacity of its dipper the new machine possesses surprising agility and one cycle of operation is accomplished in only 45 to 50 sec. Under normal working conditions the shovel will be able to move more than a million cubic yards of material per month, an amount represented by a trench 50 ft. deep, 100 ft. wide and a mile long. The boom is over 100 ft. long and the dipper handle over 65 ft. long. Material can be picked up at the working level and deposited at a point 70 ft. above this level. A mental picture of what this means can be obtained in imagining this shovel picking up a fifty ton load at street level and place it on the sixth or seventh floor of an ordinary office building.

The machine constitutes a large power plant in itself, the equivalent ratings of all the motors and generators on the shovel totaling more than 3500 hp. With the system of voltage control used, slight pressures of the operator's hands on master switch handles produce working pressures of several hundred thousand pounds at the dipper teeth.

It is interesting to speculate upon the possibilities of this machine. Suppose that it could be used to fill the storage hoppers of a large power plant. Assuming this shovel to operate 10 hr. a day, it would handle 900,000 tons of coal a month. Operating at this rate it would handle the entire coal supply for a power plant having an installed capacity of three million kilowatts operating at 80 per cent load factor.

Considering a small plant such as that at St. Mary's Academy described on page 148 of this issue, which uses some 5800 tons of coal a year, this shovel would handle the entire year's coal supply in less than two hours. Or, looking at it in still another way, the entire annual bituminous coal production of the United States, some 500,000,000 tons, could be handled and lifted a distance of 70 ft. by only 50 of these machines, operating 12 hr. a day, 300 days a year!

With the Editors

Opportunity

THAT OPPORTUNITY knocks but once is well drilled into the average individual and during depression years engineers have been preparing for the knock. Apparently the knock was made by the power curve breaking 2,000,000,000 during the latter part of last year.

At the knock, manufacturers were literally swamped by orders for equipment for projects that had been planned through the dark years of the depession, planned by individuals and industries that had limitless faith in the future of American business at a time when the majority could see but a black wall of despair devastating the country.

A large proportion of orders cover standard equipment but new developments play an important part. The latest announcement covers a 58,825 kv-a. hydrogen cooled generator driven at 3600 r.p.m. by a 46,710 kw., 1200 lb. 900 deg. F. turbine operating against a back pressure of 200 lb. ga. The main turbine will be flexibly connected to a 3290 kw. feed heating turbine operating between 200 and 5 lb. ga. with extraction at 60 lb.

When one company can report an average of better than one large turbine order a day since December 1 and another, which boasts a lion's share of the business in 1935, reports more orders so far this year than last year's entire business, it is time to get on the bandwagon and join the parade. It's too late to be a leader but after all it's better to be on Opportunity's last coach than to be left altogether.

How About the Cooling System?

AS THE LAST MONTH of Winter, March finds the heating system hanging on in grim determination to finish the heating season without major repairs. After the severe weather of January and February it seems as though the progressively mild weather of March, April and May could hardly tax the heating system, yet we know from experience that many engineers will find themselves in difficulty during the spring.

In many cases the engineer foresaw these troubles but could not get the money to make needed repairs and extensions. In others the troubles are the result of carelessness, of slip-shod maintenance which lets everything ride until needed. This attitude is conducive to neither plant morale nor good operation and should not be encouraged.

Let recent heating system troubles be a warning that summer is coming and the cooling system will soon come in for the same punishment. The cooling system bears a double responsibility, however, for it must do its own job and uphold the reputation of air conditioning for practicability.

Air conditioning is developing rapidly and is probably the biggest engineering development now before the public. There is still a great deal to be learned about air conditioning from the standpoint of comfort and physical welfare, and, as many cooling installations have been in a considerable period, there are bound to be many that were poorly engineered. It behooves the engineer to check up not only on the physical condition of the equipment but on the operating conditions as well to see if they may not be changed in the light of recent developments.

Failure of a heating system is purely a local affair while failure of a cooling system is a black eye to the industry, a breakdown of public confidence which cannot stop, but can seriously hinder, this important branch of engineering. Each engineer should do his part by thoroughly overhauling and servicing cooling equipment under his supervision and doing this before the hot weather arrives.

A Code Cannot Replace Intellect

TO THE MAN responsible for the operation of power equipment, the habit of following a specific routine is valuable, for it will save much time, energy and damage to machinery. There is, however, danger in allowing habit alone to guide you in, say, starting up a boiler. The subconscious mind may guide almost completely certain oft repeated movements of the feet and hands, and may be depended upon to a certain extent in guiding an operator through the processes of starting and stopping equipment, but a very definite danger exists here as the person going repeatedly through routine work frequently has his mind on other things than his immediate work with the result that some details are sometimes done incorrectly or perhaps not done at all.

Chief engineers and superintendents of power plants have learned that best results are secured from equipment when very definite and exact procedure is followed in the operation and care of the equipment. Left to their own initiative, probably no two operators would follow exactly the same procedure, so in any plant the wisdom of establishing a definite code of operation is well recognized. To follow a code implicitly without thought as to surrounding conditions is a tendency born of routine operation. A well planned code is probably the best guide to plant operation but along with the code should go instruction and training courses for the operators in which the reasons for each step indicated in the code are thoroughly discussed so that the operator may be fortified in case conditions are encountered, due to accident, fire or construction work, where slight changes in the routine are necessary. Although operators should be trained to observe changed conditions, the responsibility for any change in routine rests with the engineer in charge of operation and instructions should come from him, the operator's duty being to report immediately to his superior any unusual conditions that may be observed. Routine operation is essential to safety and economy but it must be used with intelligence and vigilance.

ST. MARY'S ACADEMY Cuts Steam Costs

By T. H. Bowland
Chief Engineer

MODERNIZATION AND GOOD OPERATION are co-partners in the ever present fight for lower power plant costs and St. Mary's Academy and College at Notre Dame, Ind., is an excellent example of what can be accomplished in this direction by careful planning. This is the home convent of the Sisters of the Holy Cross, a Roman Catholic Organization situated one mile west of Notre Dame University. St. Mary's showed an indomitable spirit, a progressive and sagacious management of affairs in the completion of this modernization program during the stressful years of depression.

Buildings are divided into three general groups with a total of about 125,000 sq. ft. of radiation. The College, with 35,000, and the Academy, with 65,000 sq. ft., are heated by live steam, and a group of 9 isolated buildings, totaling 25,000 sq. ft., are heated by exhaust steam. High pressure steam is also supplied for cooking and for the laundry. The new plant consists of three 300 hp. stoker fired boilers, coal handling facilities, necessary auxiliaries and a 30 t. ice machine.

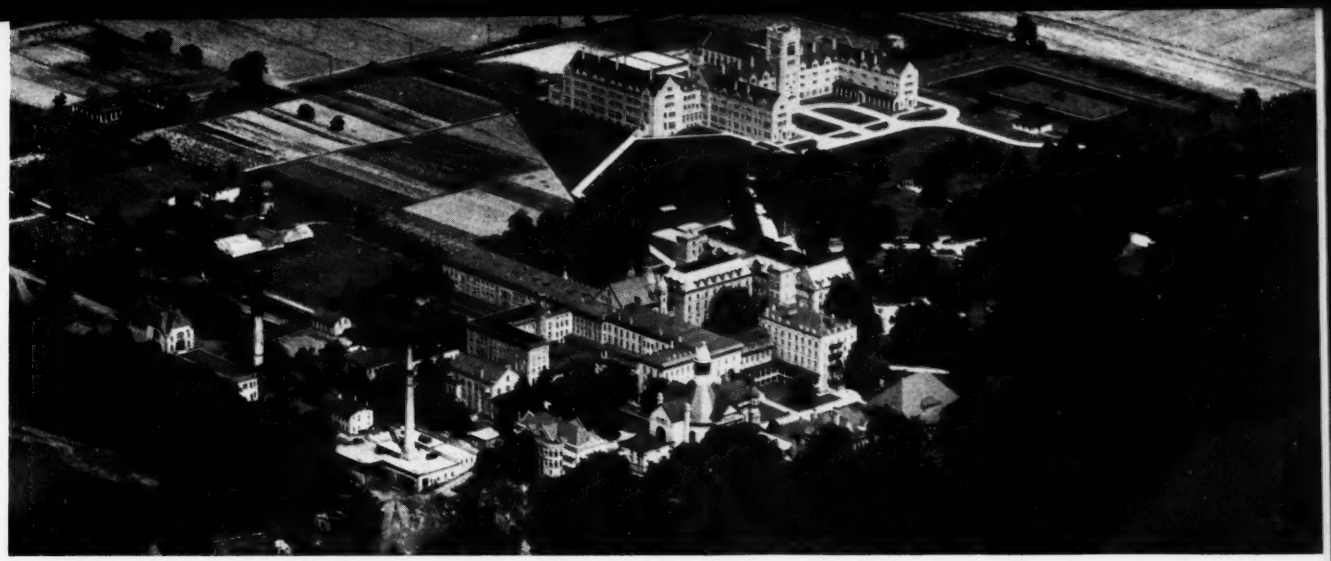
Fig. 1. The firing aisle with boiler No. 3 in the foreground

These new boilers replaced eight old boilers: four 125 hp. H.r.t.'s about 30 yr. old, two stoker fired, two hand fired; two 150 hp. Scotch marines, about 20 yr. old, with Dutch ovens; two 150 hp., stoker fired H.r.t.'s about 12 yr. old. At times all eight units were in service at the same time and it is doubtful if the combined steam output exceeded 25,000 lb. per hr. When the writer went to St. Mary's in 1933 his first concern was accurate knowledge of load conditions and the maximum recovery of heating returns for feedwater purposes.

Information on load was obtained by installing a Brown recording flowmeter but the feedwater problem required more equipment and effort. At that time returns from the two live steam systems, totalling about 100,000 sq. ft. of radiation, were pumped to a large open tank and fed to the boilers at about 150 deg. F. Returns from the 25,000 sq. ft. heated by exhaust steam, badly contaminated with oil, were pumped to the sewer. Manzel lubricators were installed on all pumps and the steam cylinder oil consumption cut about two thirds, that is from 15 to 5 bbl. a year. The returns were then piped to a two compartment tank, properly baffled to separate the oil, and, after the system had been cleaned out somewhat, the returns were reclaimed for boiler feed purposes.

Installation of an Elliott 50,000 lb. per hr. deaerating heater and vent condenser solved the problem of boiler feedwater and raised the temperature from 180 to 216 deg. F. for a very modest investment. At the same time a Bailey weir meter was installed to give an accurate record of the feedwater flow. Next, Swartwout master reducing valves were installed for regulating the heating system pressures. The exhaust steam system is maintained at a slightly higher pressure than the live steam system and as the valves are now arranged the exhaust steam system is maintained between 1 and 2 lb. pressure. If the pressure drops below 1 lb., live steam is admitted, while if the pressure goes above 2 lb. the excess spills over to the live steam system through a Swartwout master controlled relief valve. Formerly this excess was vented to atmosphere through the exhaust head while the present arrangement gives practically a closed system and low makeup.

These changes were all made as a part of a comprehensive modernization program that was completed



as soon as sufficient data on load had been collected to justify selection of the proper size boilers. Studies indicated that three 300 hp. stoker fired boilers designed for continuous operation at 20,000 lb. of steam per hr. each, would best answer the purpose, as two boilers could carry the load in the most severe weather, leaving the third unit in reserve. C. C. Wilcox of South Bend was retained as consulting engineer.

As installed, the plant consists of three 300 b.hp. Union Type L boilers, fired by sprinkling type stokers designed to evaporate 20,000 lb. per hr. continuously and 25,000 for 2 hr. peaks with forced draft, or, up to 10,000 lb. per hr. with natural draft from a 145 ft. stack, 5 ft. in diam. at the top. Although boilers are operated at 115 lb. ga. they are designed for a maximum working pressure of 199 lb. leaving the way clear for the addition of electric power generating equipment at a later date if conditions warrant. At present power is purchased, the load ranging from perhaps 10 to a maximum of 100 kw. Each stoker is dual driven by a 1 hp. Louis Allis motor and a 1½ hp. Carling turbine. Forced draft is provided by individual Clarage, Type H.S.V., steel plate fans with a capacity of 11,000 c.f.m. at 3 in. S.P. and 1678 r.p.m. Each fan is driven by a 10 hp. Whiton steam turbine.

Combustion Control

A Hagan steam pressure regulator controls: the fuel feed by regulating the stoker of the feeder; the air supply by means of inlet vanes on the fans; the furnace draft by the uptake damper. If the stoker is being driven by motor the control is arranged to stop and start the motor within the pressure limits set by the regulator adjustments. Minor adjustments to keep the pens on the Bailey boiler meters together are made by hand and these meters, which also have flue gas temperature pens, are set for 12 per cent CO_2. Hays 3-pointer draft gages indicate ash pit, overfire and uptake pressures.

Furnaces, 7 ft. wide, with a total volume of 927 cu. ft., giving a heat release of about 15,000 B.t.u. at 150 per cent rating, have one row of Bernitz air cooled bricks along the sides and back. With the exception of the Laclede-Christy suspended arches on the stoker rotors, the balance of the wall is of first and second quality fire brick backed up with salt glazed brick. The 18½ in. wall required approximately 36,000 fire brick, Laclede-Christy refractories being used in one, A. P. Green in another and Harbison-Walker in the third, each brick being laid up with its own high temperature cement. A siftings hopper is provided under the second pass and arranged for discharging direct to a wheelbarrow. Ashes are removed from the front of the ashpit by means of a shovel and taken out in a wheelbarrow.

Coal is received by rail on a siding about ¾ mi. distant and trucked to the plant where it is stored in a 200 t. Fairfield silo. The handling facilities consist of a hopper forming the boot of a 20 t.p.h. bucket elevator which discharges to the top of the silo. The top part of the silo has a shelf which holds about 40 t. of coal and feeds by gravity direct to a 1 t. hand operated weigh larry which serves all three stoker hoppers. Coal beyond the 40 t. stored on the shelf falls to the bottom of the silo and remains in storage till needed. The bottom of the silo has a gate which feeds the boot of the elevator by gravity so that the stored coal may be elevated to the top shelf as needed.

Other boiler auxiliaries and appurtenances include: Crane stop and check and miscellaneous steam valves;

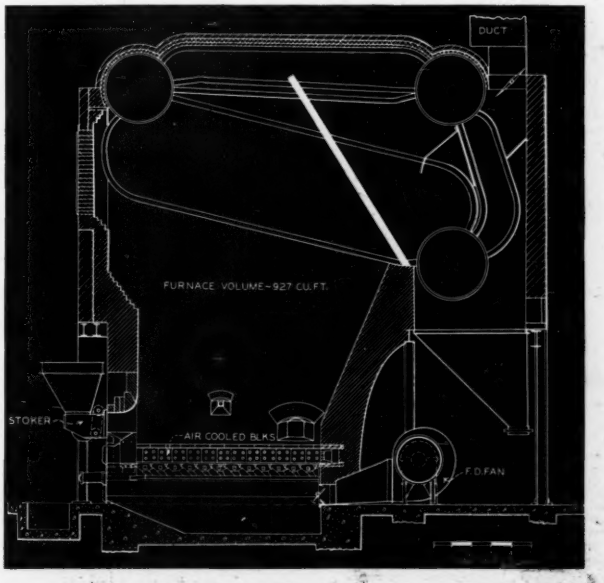


Fig. 2. Cross section of the boiler showing the stoker and setting arrangement

Consolidated-Ashcroft-Hancock safety valves; Walworth globe and check valves in feed lines; Yarway blowoff valves; Reliance water column with Huyette gage cocks and Westinghouse gage glass illuminators; Crosby steam gages; Bailey feedwater regulators; and Diamond soot blowers. Two boiler feed pumps, one Union 10 by 6 by 10 in., duplex and one American 12 by 8 by 12 in. simplex were reclaimed from the old plant as were the four vacuum return pumps, all American simplex, ranging in size from 6 by 8 by 12 in. to 10 by 12 by 16 in. Increased furnace turbulence for burning low grade coal at higher ratings and good efficiency is provided by Combustion Aids, which include two steam jets, one on each side of the furnace. Each jet has a 3/32 in. orifice and the steam pressure on the jets is regulated by hand in accordance with operating needs, 40 lb. being about right for average conditions.

Refrigeration

In addition to heat, the plant supplies the entire academy with refrigeration and hot and cold water. Being outside the city limits of South Bend, city water is not available and the necessary supply is pumped from six wells. Five of these wells are pumped by one of three Worthington duplex steam pumps through a common suction line. The largest of these pumps, a 14 and 20 by 12 by 15 in., is kept for fire purposes and arranged so that it may take its suction through an 18 in. line from the St. Joseph River in emergencies. A 12 by 7 by 12 in. pump is kept in reserve and a 12 and 18 by 10 by 12 in. is kept in regular operation under control of a Fisher governor to maintain a 60 lb. pressure on a 60,000 gal. standpipe. In addition to these steam pumps, a new 400 g.p.m. Sterling deep-well pump driven by a 30 hp., Howell motor pumps a sixth well. This pump is under the control of a Cutler-Hammer pressure control switch set with 55 and 60 lb. pressure limits.

Well water on the way to the standpipe serves as cooling water for the refrigeration condensers. Refrigeration is supplied to all buildings by circulating brine at 10 deg. F. An old 15 t. CO_2 compressor was replaced by a 30 t. Worthington steam driven unit with a Gardner governor and McCord lubricator. A 7½ by 6 by 10 in. Worthington duplex steam driven brine pump was also added to supplement the 10 by 6 by 10 pump which had been carrying the load alone. In addition to the new 30 t. machine a 25 t. Brunswick-Kroeschell unit is available for use although it is hardly large enough to carry the load during the summer months. Hot water is first softened by two Wayne Zeolite softeners (25,000 gal. capacity per regeneration) and heated by two closed hot water heaters located just above the feedwater heater as shown in the longitudinal section of the plant.

Operating Results

With the coal scales, feedwater meter and steam meter, the overall performance of the plant is easily and accurately determined. In addition, 6 Taylor and 6 Brown recording pressure and temperature gages give a permanent record of operation and indicating thermometers and pressure gages are available for operating guides. The indicating pressure gages include Marsh, U. S. Gauge, Crosby and Marshalltown.

So far the best month's operation showed a fuel cost of 18 cents per 1000 lb. of steam. The coal burned was Indiana 5 vein running 11,200 B.t.u. per lb. and costing $2.95 delivered. The total evaporation was 11,852,000 lb., and coal burned 706 t., giving an overall efficiency of 74.5 per cent and an equivalent evaporation of 8.59 lb. During January a total of 13,680,000 lb. of water were evaporated by 825.94 t. of Glendora 1¼ in. screenings.

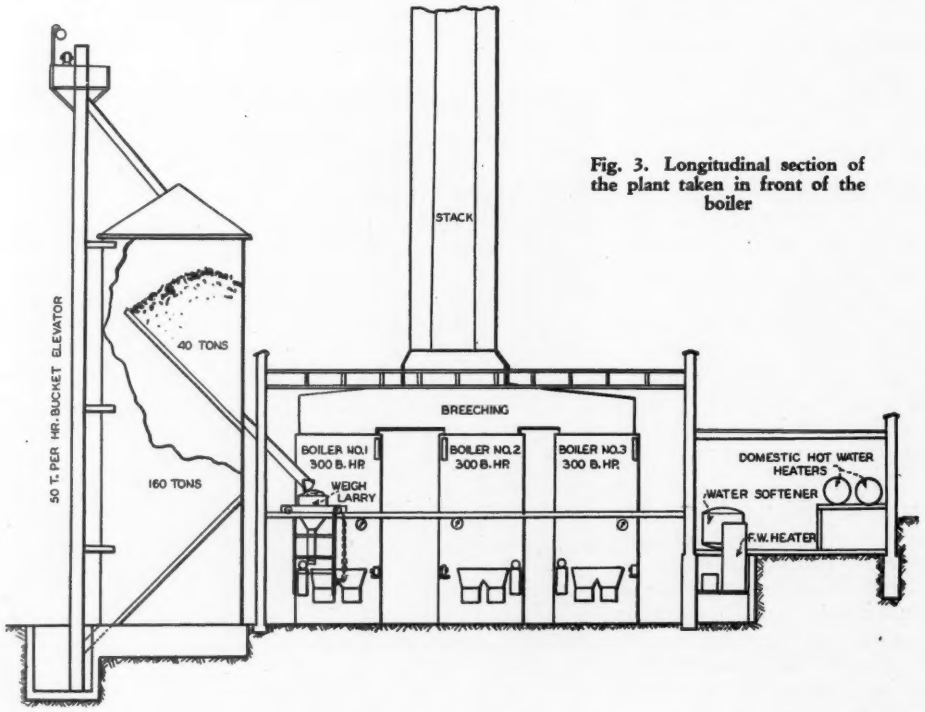


Fig. 3. Longitudinal section of the plant taken in front of the boiler

During the seven years, 1926-1933, the average annual coal consumption was 8688 t. at an average cost of $4.32 per ton. This was decreased to 7366 t., at an average cost of $3.32 per ton, in 1934 and to 5885 t., at an average cost of $3.22, in 1935. The 1934 saving was due largely to improved operation and the 1935 saving to the new boiler plant so that the new equipment is paying a handsome dividend and there is no question of the plant paying for itself in less than the 5 yr. originally estimated.

Density *and* Boiler Circulation

By R. L. SCORAH
University of Missouri

As boiler pressures and temperatures increase, the difference in densities between water and steam decreases, giving rise to trouble with natural boiler water circulation. Forced circulation offers one solution.

TREND TOWARD higher steam pressures and temperatures has made such rapid progress in the last decade that steam conditions up to about 1500 lb. per sq. in. and 800 deg. F. may be considered within the realm of conventional boiler practice. Thus far, however, the pressures and temperatures for greatest overall economy have not been determined since these optimum conditions depend on the as yet incomplete knowledge of the design and construction of apparatus for the production and use of high pressure steam at a minimum cost. Although a number of novel boiler arrangements have been proposed and several experimental boilers are under laboratory investigation, it is significant that the Benson critical-pressure boiler, the Loeffler steam circulating boiler, and the special bent-tube design at Philip Carey are already in commercial operation.[1] Among the leading influences on the development of new boiler types for extremely high pressure service is the marked change in the properties of water and steam in this region.

The property of density plays a leading role in considerations of circulation, hence, in the arrangement of heating surfaces. The general behavior of density, or its reciprocal, specific volume, is beautifully illustrated by plotting a three-axis diagram of the equilibrium values of pressure, temperature and specific volume. The result is the state surface of steam[2] shown in Fig. 1. These data for conditions ranging from 32 deg. F. to 1000 deg. F. and pressures up to 3500 lb. per sq. in. absolute are given in Keenan's Steam Tables and Compressed Water Tables.[3] For completeness, the state surface can be extrapolated from 32 deg. F. down to absolute zero, the necessary data, although as yet incomplete, are summarized in the International Critical Tables. The scales of this diagram have been modified to reveal clearly some of the more interesting details.

Very briefly the state surface of steam may be described as follows: The wet steam conditions define a cylindrical surface perpendicular to the P-T plane and extending from absolute zero to the critical point where the specific volumes of saturated water and steam become equal. The coördinates of the critical point are p = 3226.0 lb. per sq. in. absolute, T = 706.1 deg. F., and v = 0.0522 cu. ft. per lb. In a similar way, the P, V, T relations for mixtures of water and ice define another cylindrical surface perpendicular to the P-T plane. These two cylindrical surfaces intersect on the element AB of the wet steam surface and this line AB represents the triple point conditions where ice, water, and steam may coexist in equilibrium. The coordinates of the triple point are P = 0.0887 lb. per sq. in. absolute, T = 32.0135 deg. F., and the specific volume may range between A and B depending upon the proportions of ice, water, and steam present in the mixture. The remaining areas of the state surface represent the various possible equilibrium states of ice, water, and superheated steam.

Steam Generation Considered as Constant Pressure Process

Neglecting for the moment the variations of pressure within a boiler, the steam generating operation may be considered as a constant pressure process and represented by a constant pressure line on the state surface. Such a line for a pressure of, say 700 lb. per sq. in. absolute, would be the line CD, and the perpendicular distance from any given point on this line to the P-T plane would be proportional to the specific volume of the state represented by that point. In a similar way, the line EF would serve for a constant pressure of 2000 lb. per sq. in. absolute, and the line GH, for a constant pressure equal to the critical pressure. In order to compare these lines on the more common two-dimensional graph in which the specific volume for a given pressure is shown as a function of temperature, it is necessary to project these lines onto a V-T plane such as the the plane xyz in Fig. 1. With a three-dimensional model of the state surface, it would only be necessary to turn the bottom up to observe this V-T plane. An equivalent operation is performed in Fig. 1 by imagining the plane xyz hinged

[1] Benson, Power Plant Eng., 37, 378 (1933); 34, 612 (1930). Loeffler, Power Plant Eng., 33, 588 (1929). Philip Carey, Power Plant Eng., 37, 15 (1933). Experimental, ASME Trans., RP-54-1a and 1b; Mech. Eng., 53, 883 (1931).
[2] Described in Power Plant Engineering, 38, 172 (1934).
[3] Mechanical Engineering, 53, 127 (1931).

along the line yz so that it can swing down into view as the vertical plane x'yx.

Only a part of the line CD has significance in the usual steam generating process for the working substance does not enter the boiler at absolute zero but at some higher temperature, say 300 deg. F. This state is represented by point I on the 700 lb. constant pressure line. To generate steam at 700 lb. pressure and 1000 deg. F. total temperature, each pound of feed-

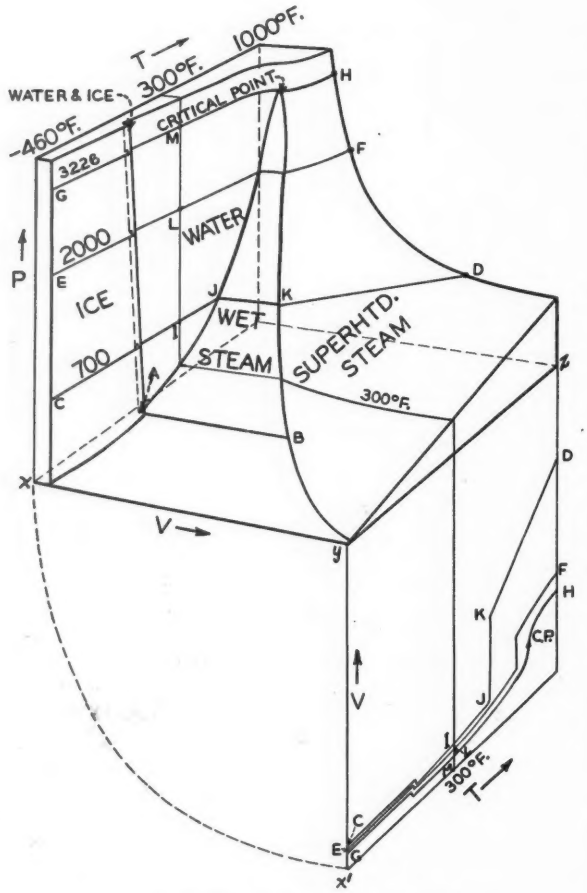


Fig. 1. State surfaces of water in various forms

water must first be heated to the saturation temperature, thus moving the state point from I to J. Second, each pound of saturated water must be vaporized to saturated steam, moving the state point from J to K. Finally, in the superheating element of the steam generator, the saturated steam is heated to the final temperature of 1000 deg. F., bringing the state point from K to D. In the 2000 lb. boiler, the same sequence of events moves the state point from L to F, but for boiler pressures equal to or greater than the critical pressure, there is a spectacular difference—the phenomenon of "boiling" no longer occurs since these constant pressure lines no longer cross the wet steam region of the state surface.

The state surface, or its projection on the V-T plane, visualizes the change in specific volume which accompanies the above steam generation processes. The reciprocal of specific volume is density whose variations along the circuit of flow are the primary cause of natural circulation in a conventional boiler. These variations in density are due in part to differences in the temperature of the liquid but largely to the uneven distribution of vapor bubbles. These bubbles not only produce large local changes in the average density of the fluid but also exhibit the phenomenon of buoyancy which gives them a tendency to move upward, dragging, through viscous action, a bit of the adjacent liquid with them. Neglecting the effect of surface tension, the buoyancy of a vapor bubble for a given saturation pressure and temperature depends upon the unequal densities of the vapor and liquid. In a steam boiler, these differences in density cause an upward movement in that portion of the flow circuit containing many steam bubbles suspended in the warmer, less-dense water, and a corresponding downward movement in that part of the circuit where few or no steam bubbles are suspended in cooler, denser water.

Critical Pressure Conditions

An inspection of the state surface of steam will show that as the pressure is raised, the specific volumes, and hence, the densities of saturated water and steam approach each other and become equal at the critical pressure. Hence, the ability of steam bubbles to augment changes in the average density must diminish to zero as the pressure is raised to the critical value. For boiler pressures above the critical, it is at once clear that no steam bubbles will be available to help create the large differences in average density necessary for rapid circulation. For boiler pressures below the critical, the full difference between the densities of saturated water and steam cannot, unfortunately, be used to produce circulation since this condition would require the rising portion of the flow circuit to be filled with dry steam. Ordinarily, this part of the circuit would be located inside of a boiler tube, and such a tube would be "steam bound" and in danger of being burned unless especially constructed for such service.

As a first approximation to the actual conditions in the flow-circuit, the value of the ratio z, the volume ratio of steam to water required to avoid the danger of a tube becoming steam bound, can be taken as the mixture 6 parts of steam bubbles by volume to 4 parts of water by volume. At each boiler pressure, this mixture will have a certain steam *quality*, and a certain *difference* between the density of saturated water and the density of the safe mixture. These two quantities have been computed and plotted in Fig. 2 which includes, for comparison, the difference between the densities of saturated water and vapor.

It will be observed that although the quality of the safe mixture increases with pressure, the actual density difference available for circulation purposes decreases. To this result must be added the probable necessity of lowering the value of the ratio z, the probable existence of vapor bubbles in the descending portion of the flow circuit, the increase in the average viscosity of the steam-water mixture, the probable decrease in tube diameter—all of which would tend to have an adverse effect on natural circulation as the boiler pressure is raised. On the other hand, for a given value of the ratio z, the quality of the rising mixture is considerably larger at high pressures so that less circulation is needed to deliver a given amount of steam. It is interesting that, on one hand,

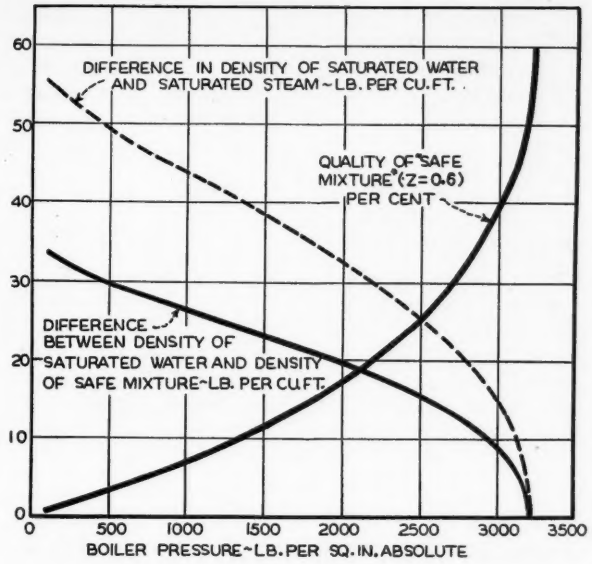


Fig. 2. Variation of difference in density with pressure

the Philip Carey boilers and several of the experimental designs[1] depend on natural circulation while in the Loeffler, Benson, and Purdue[1] boilers, the flow of the working substance is achieved by mechanical means.

The flow circuit of a steam boiler, however, is most usually subdivided into many headers and tubes and, in some cases, water walls and slag screens. In natural circulation designs, nature is allowed a pretty free hand in distributing the flow and specifying the velocities in these many channels. While forced circulation does put great dependence on a pump, the distribution and the velocities can be adjusted to the optimum conditions. For this reason, another decade may see forced circulation not only established for high pressure service but also entering the moderate pressure field now held by natural circulation boilers.

JOHNS-MANVILLE CORP. has announced the start of an extensive plant expansion program, calling for erection of a new $750,000 roofing plant at New Orleans and modernization and expansion of the Waukegan, Ill., and other building material plants over the country for a total expenditure of approximately $1,500,000. The announcement was made by Lewis H. Brown, president of Johns-Manville.

This expenditure of $1,500,000 follows a 10-months program in 1935 that saw $1,000,000 spent by Johns-Manville in modernizing plants and installing new equipment. It is part of a continuous program of plant modernization which, it is thought, will be required and justified by increased demand in the next few years.

The first unit of the New Orleans plant will replace one now operating in leased quarters and will, when in full operation, give work to 400 men. It is expected to be in operation early this summer.

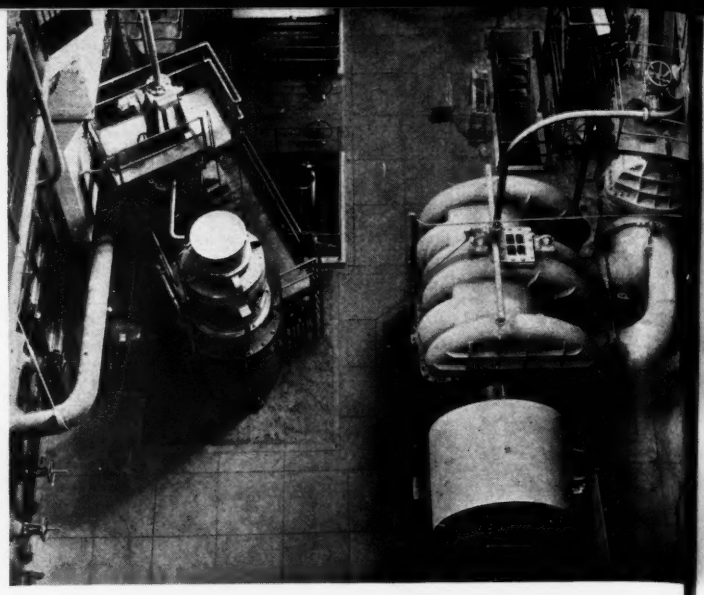
Relays That "Remember"

RELAYS THAT "REMEMBER" are being used on the main-line electrification of the Pennsylvania Railroad between New York and Washington. The Pennsylvania's electrical line uses 11,000 v., 25 cycles, single phase for the trolly circuits. The trolleys are protected by high-speed circuit breakers, a great many of which have impulse, or rate of rise, tripping. Supplementing this protection, a group of G-E directional distance relays of the single-step variety, consisting of one starting unit and one ohm unit,—are employed. High-speed induction-cylinder units are used. The first requirement that had to be met was that the relays must not operate on less than 1 cycle (25-cycle basis) or 0.040 seconds of fault duration. The impulse trip takes that length of time to clear on completely displaced waves near the maximum fault current. To meet this requirement, a seal-in relay was used which requires 1 cycle of continuous energization through closure of the contacts of both the ohm and the starting units in order to pick up and trip the breaker.

This installation also required that the relays provide absolutely correct operation on zero volts. There are no circuit breakers in the electric locomotives, faults being cleared by automatically grounding the trolley and letting the station breakers open the circuit. If the locomotive should become faulty when near the relay station, there would be practically zero volts on which to work. Correct operation is assured by having the relay "remember" what the voltage was just before the fault occurred. "Memory action" is obtained by using the properties of a tuned circuit. In a tuned, or resonant, circuit, energy is alternately stored in a capacitor and a reactor, the total stored energy in the two being a constant amount for any and all points in the voltage time wave. Should a fault occur which results in zero volts, the potential circuit is short-circuited, while the potential-coil current continues at the same frequency—with a decay in magnitude.

The relays must also be able to distinguish between fault currents and magnetizing inrush currents—the latter currents occurring when the locomotive transformers are energized, and requiring a high setting of the rate-of-rise relays. The starting unit makes this distinction possible, since it operates only when the magnitude of the fundamental component of the current, compared with the voltage, indicates a fault. Magnetizing inrush current is composed of many harmonics, and since only 40 to 50 per cent of the total rms. value is of fundamental frequency, the relay is only 40 to 50 per cent as sensitive to magnetizing inrush currents as to fault currents.

THE WORLD'S LARGEST artificial lake, that formed by construction of Boulder Dam on the Colorado River, has been officially named Lake Mead, honoring the late Dr. Elwood Mead, Commissioner of Reclamation.



113,000 SQ. FT. *in a* SINGLE CONDENSER SHELL

World's Largest Condenser at Richmond Station presented many problems for designers

By D. W. R. MORGAN
Engineering Division
Westinghouse Elec. & Mfg. Co.

RICHMOND STATION of the Philadelphia Electric Co. has a 165,000 kw. turbine served by a 113,000 sq. ft. surface condenser which in turn is supplied with cooling water by two 66 in. diameter propeller type pumps having a combined capacity of 152,000 g.p.m. The 218,880,000 gal. of water which pass through the tubes of this condenser in 24 hr. would more than satisfy the needs of a large city and the tubes themselves would reach from New York to Philadelphia, approximately 100 mi. Some 17,630, 7/8 in. O.D., No. 18 B.W.G. tubes with an active length of 28 ft. 0 in. are installed and the weight of condenser complete with the tubes is 695,300 lb. dry and 969,300 lb. with the circulating system wet. The diameter of the tube plates is 19 ft. 8 in. and the diameter of the shell 28 ft. 8 in.

This shell is of welded steel construction, the main portion consisting of 3/4 in. copper bearing steel made up of seven sections. The condenser was assembled completely at the place of manufacture and the several sections, made thus to facilitate shipment, fitted and doweled. Due to the small clearance between the condenser and turbine foundation, it was necessary to assemble the condenser in place prior to the pouring of the main foundation structure, so, obviously all of the major sections of the shell were welded in place at the point of installation.

Tubes are rolled into each tube sheet eliminating any form of packing, and the tubes bowed three in. for drainage. With the tubes rigidly fixed in the tube plates, it is necessary to compensate for any difference in expansion between the shell and tubes. For this purpose a diaphragm is provided at each end of the shell, sufficiently flexible to permit of any movement that may take place, and in addition this diaphragm forms the end wall section between the shell and water box flanges. The exterior part of the shell is free of reinforcement members, such elements being located within the shell.

As the condenser is solidly connected to the turbine exhaust flange, a counterweight arrangement is provided under each condenser foot in order to relieve the turbine of the full condenser load. The desired loading is obtained by adjusting the counterweights. This form of support is used in preference to springs or expansion joints, as it assures practically a constant load on the turbine exhaust, because expansion in the turbine and condenser is compensated for by a movement of the lever arms.

Space available for the condenser allowed the designer considerable latitude in the selection and arrangement of the tube nest. In general, the objective sought is an arrangement of tubes that will render each square foot of the tube surface active with the least disturbance to flow; second, minimum resistance to flow, or in other words, a structure having the least pressure drop from the steam inlet to the air offtake. The third requirement is to deliver condensate from the condenser at a temperature corresponding to the temperature of the entering steam.

The 113,000 sq. ft. of surface installed represents the largest amount of tube surface within a single shell, about 13 per cent more tube surface than the largest units formerly in service and 38 per cent more tubes due to the shorter tube length used. From the standpoint of steam distribution, the greater number of tubes complicates the design and introduces the possibility of a greater pressure drop through the tube nest.

Prior to the completion of the final design certain laboratory work was undertaken applicable to this specific case. Space does not permit a complete review

of this phase of the development but the methods employed are outlined below sufficiently to illustrate the plan of attack. This research work was undertaken to determine the most desirable method of securing uniform distribution of steam to the entire tube nest, and to so dispose the tubes to obtain substantially equal flow lines with respect to the pressure differences between the condenser steam inlet and the air offtake.

In passing it should be stated that while the turbine manufacturer can possibly obtain a uniform distribution of steam from the turbine, it generally is accomplished at the expense of increasing the back pressure at the last row of blades which is detrimental to the economy of the unit. It is, therefore, expedient that the designer of the condenser recognize such variations and so dispose the tubes that substantially uniform distribution of steam will be secured throughout the tube nest.

Figure 5 shows the general arrangement of the turbine exhaust and attached to it a model of the condenser. The turbine model is connected to a large tank into which air is pumped by a blower, and from which air is admitted to the model. The exhaust annulus of the turbine model is provided with twisted vanes, guiding the air flow in a manner approximating the flow from the actual turbine. The instruments at the left of the picture are manometers for measuring velocity-pressure. The model shown by this figure represents one-half of the condenser parted at the vertical centerline. The rectangular opening at the top corresponds to one-half of the turbine exhaust opening, and the section at the right of the illustration represents the vertical centerline of the condenser which exposes the location of the main tube supports indicated by the five vertical members.

Figure 3 is typical of the research work which was done and illustrates to what extent the distribution was affected by changes in the arrangement of tubes. As an example, the four charts at the left hand side of the illustration reading from top to bottom, designate respectively the pressure and velocity distribution at the condenser steam inlet flange for a given arrangement of tubes. The third illustration indicates the distribution over the tube surface which existed between the tube plate and the first tube support, between the first and second tube support, and

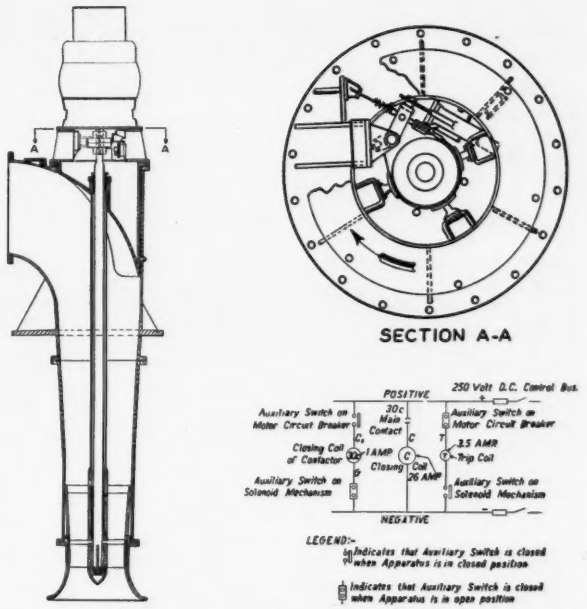

SECTION A-A
POSITIVE
250 Volt D.C. Control Bus
Auxiliary Switch on Motor Circuit Breaker
30c Main Contact
Auxiliary Switch on Motor Circuit Breaker
Closing Coil of Contactor
1 AMP
Closing Coil 20 AMP
3.5 AMR Trip Coil
Auxiliary Switch on Solenoid Mechanism
Auxiliary Switch on Solenoid Mechanism
NEGATIVE
LEGEND:-
Indicates that Auxiliary Switch is closed when Apparatus is in closed position
Indicates that Auxiliary Switch is closed when Apparatus is in open position

Fig. 1. Vertical circulating pump and schematic diagram of control connections for circuit breaker operating mechanism used with motor brake

beween the second and third tube support. Similarly the diagram at the bottom indicates the distribution in the areas between the remaining tube supports. The vertical line represents the vertical centerline of the condenser, the circle represents the periphery of the tube nest. The shaded area of these two illustrations shows quantitatively the unequal flow distribution, the greater portion entering the tube area nearest the turbine exhaust. The corresponding figures at the right of the figure show the improvement in distribution obtained by modifying the spacing and arrangement of tubes.

One of the principal difficulties of a test of this nature is to determine static pressure with sufficient accuracy and ease to permit a large number of readings to be taken. A double impact tube, devised by Fechheimer in connection with air flow in electric machines, has been found to be of great value in this connection. With this device it is comparatively sim-

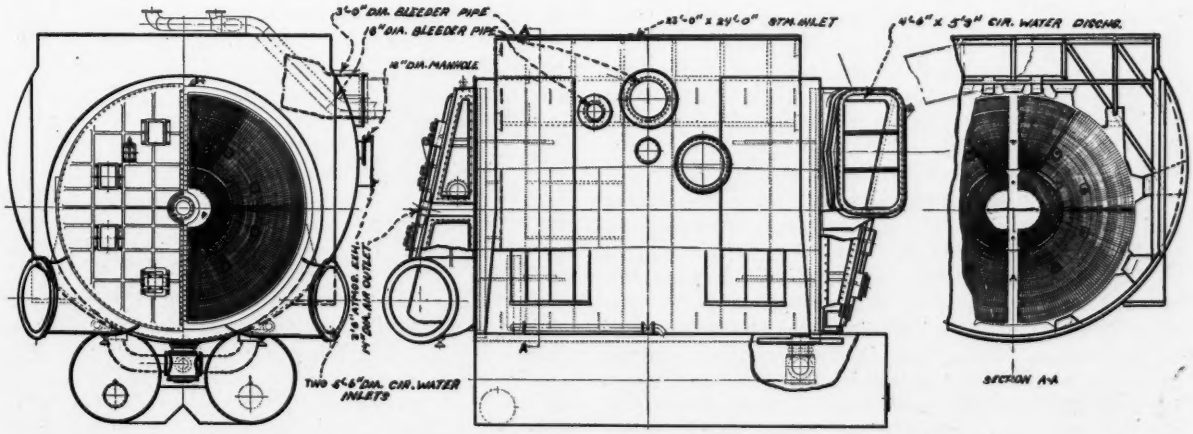

3'-0" DIA. BLEEDER PIPE
18" DIA. BLEEDER PIPE
18" DIA. MANHOLE
22'-0" x 24'-0" STM. INLET
4'-6" x 5'-9" CIR. WATER DISCHG.
TWO 6'-6" DIA. CIR. WATER INLETS
SECTION A-A

Fig. 2. General arrangement of the shell tube bank and condensate reservoirs

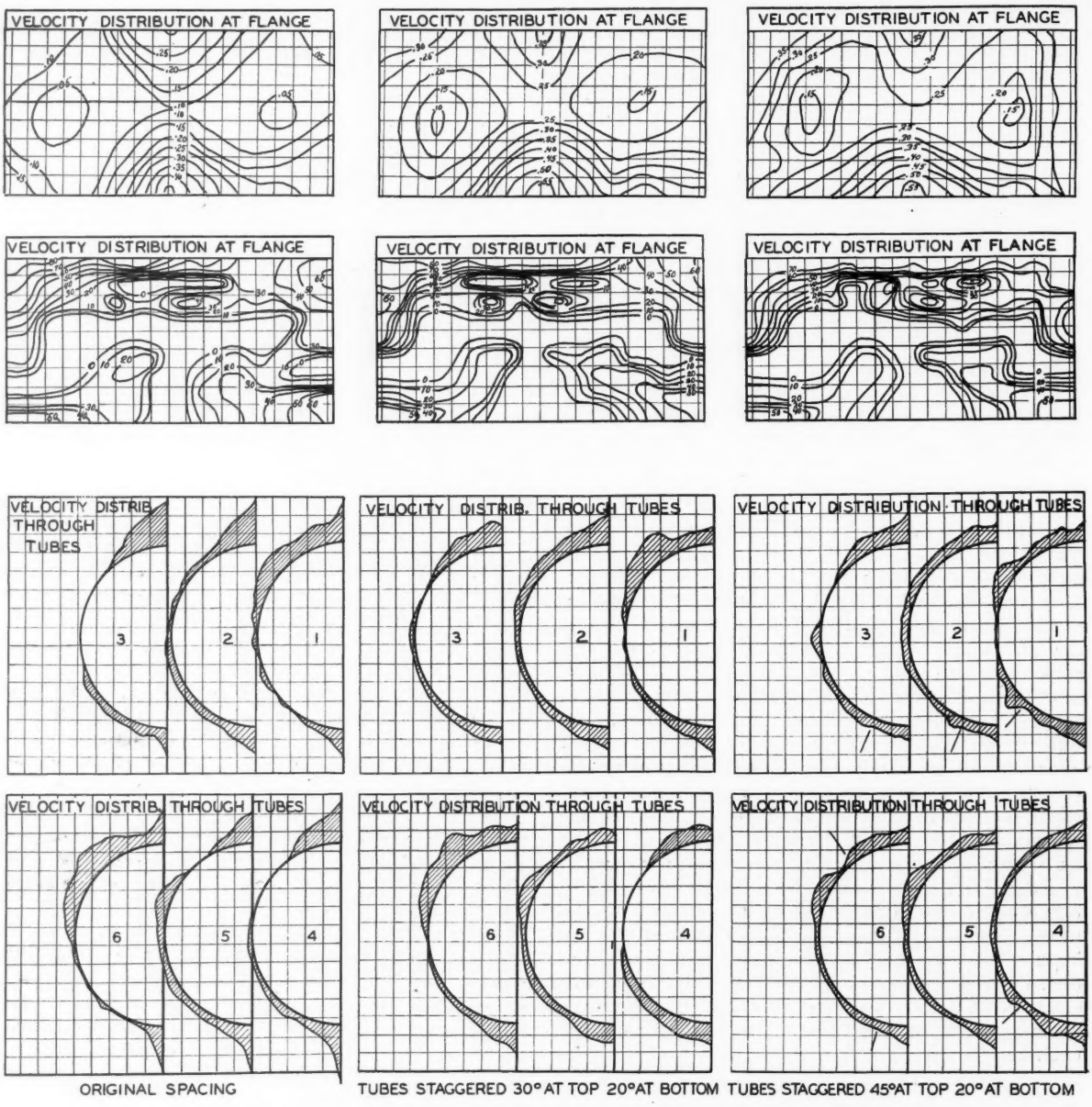


Fig. 3. Pressure and velocity distribution for various arrangements as indicated

ple to take readings of static pressure parallel with, and at right angles to, the direction of flow.

Figure 2 shows a general arrangement of the condenser having the steam inlet located in a conventional position at the top. There are two circulating water inlets and one outlet. This particular design was adopted because it provided substantial areas for distribution of steam longitudinally than would obtain had we employed a tube arrangement corresponding to the conventional straight down flow type.

Figure 4 shows a typical longitudinal diagrammatic arrangement of tube supports and steam baffles, the air offtake being located substantially at the center of the tube nest. At the water inlet end of the condenser an annular baffle construction is used, and the division between the outer and inner annulus segregates a portion of the tube surface which functions as an air cooler. This arrangement permits maximum utility of the tube surface throughout the tube length. The process of condensation follows certain natural laws, and it is obvious that the cold end of the condenser has the greatest condensing capacity, which means that less surface is required to condense a given amount of steam. Therefore, in order to approximate equal distribution of steam to the various tube sections, a portion of the less active tubes at the cold end may be isolated conveniently, and efficiently used for reducing the temperature of the non-condensible vapor.

It will be noted that the tube nest is free of any devices that would materially restrict the flow of steam. Further, it will be noted that very liberal sized openings are provided at the center of the tube bank for the passage of air laden steam, access being through openings in the central annulus until the mixture enters the section between the second and third

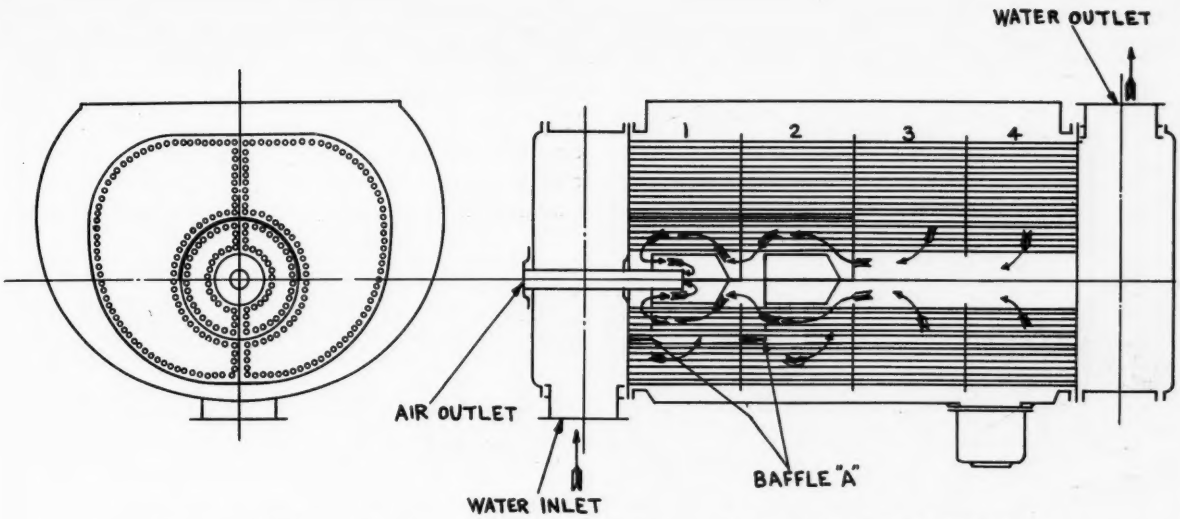


Fig. 4. Arrangement of air outlet and air cooler section and baffle at inlet end of tube bank

tube support, where the flow is diverted and passes over tubes in the two air cooler sections located at the water inlet end of the tube bank.

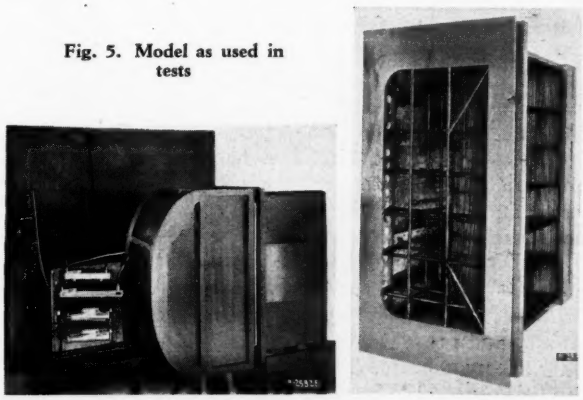
As applied to single pass condensers, the objective is to obtain the greatest amount of condensing activity with the least amount of pressure drop without attempting to restrict the distribution of steam longitudinally. It is our opinion that the most efficient design of condenser is that in which no attempt is made to interfere with the natural laws. For that reason the design involves a principle of construction that will result in a minimum of pressure drop from the turbine exhaust of the air offtake.

The illustrations shown disclose the fact that a portion of the tube surface at the cold end is enclosed by an annulus, segregating a portion of the less active surface which functions as an air cooler, thus reducing the temperature and volume of non-condensible vapor. Further, it is evident that nothing has been done to interfere with the longitudinal distribution of steam, which feature we regard as desirable for the Philadelphia Electric condenser which serves a double flow turbine.

Cooling Water Pumps

General arrangement of the 66 in. diameter propeller type pump used for the cooling water supply is shown by Fig. 6. This form of pump is admirably suited for this class of service where a large quantity of water at relatively low head is required. Each motor driven, 400 r.p.m. pump has a capacity of 77,500 g.p.m. pumping against a total head of 16.6 ft.

Fig. 5. Model as used in tests



Reversal of Rotation

A non-reversing mechanism is provided to prevent the water from reversing the direction of rotation of the unit if its motor should fail. This mechanism consists of a band brake acting on the periphery of the hub of the coupling. The end of the brake bands are attached to a lever, which is fulcrumed with unequal lever arms so that when the solenoid mechanism releases the pull on this lever, the band grips the hub through the action of a spring to prevent reverse rotation.

Further, this type of pump eliminates the necessity of priming the circulating system because the propeller is submerged, whereas a centrifugal pump is generally located at the basement floor level necessitating a suction lift. The submerging of the propeller is conducive to elimination of air from the circulating system, which generally results in lower maintenance of pump parts as well as tubes.

The headpiece illustrates the space occupied by the propeller type pump as compared with a pump of the centrifugal type. These pumps are of substantially the same capacity. The propeller pump serving the 113,000 sq. ft. condenser is shown at the left of the illustration and the centrifugal pump is shown at the right serves a 70,000 sq. ft. condenser. The difference in space requirements is apparent.

Air Removal Equipment

Steam ejectors, of the conventional type, are used for the removal of air and non-condensible vapor in the condensing system. There are two separate units, each unit carrying three two-stage condensing type ejectors, each ejector having a capacity of 10 c.f.m. of dry air, plus the water vapor sufficient to saturate this air at 7½ deg. F. below the temperature corresponding to 29 in. vacuum.

If you had to prepare detailed directions for the operation of your power plant, could you sit down and write an operating code that would meet the demands of safety, maintain efficiency and be intelligible to the personnel

What Would YOU Do?

AS THE COMPLEXITY of the modern power plant increases, the need for careful operation becomes more evident and if full advantage is to be taken of the economy potentialities built into the plant, this need becomes a necessity. Furthermore, there is the ever present requirement for safety of equipment and human life which become more exacting as temperatures and pressures increase and boiler ratings are pushed higher and higher.

Fulfillment of these various requirements demand concerted coöperation and the definite assignment of responsibilities to members of the operating crew. This can be accomplished only by a detailed operating code which may exist only in the heads of one or two experienced men, or, which may be reduced to writing and made available to the entire crew, particularly the junior members who it is expected will some day have to take over these duties or may have to do so in an emergency.

Improves Operation

Preparing detailed written instructions for a single piece of equipment is often difficult, but to prepare such instructions for a complete plant is much more difficult, so much so that it is done in few central stations and fewer industrial plants. That there is a definite need for such codes is shown by requests for information from all sections of the country and all types of plants. Among central stations the demand was sufficiently insistent to warrant the appointment, by the old N.E.L.A., of a special committee to formulate an Operating Code, the last revision being published on pages 1131-1151 of Volume 86 (1929) of the proceedings.

One of the few industrial power plants with a complete and detailed operating code is that of Hiram Walker & Sons, Inc., serving the Largest Distillery in the World at Peoria, Ill. This plant (for details see the following three articles in Power Plant Engineering: The World's Largest Distillery, Part I, page 398, September, 1934; Part II, page 454, October, 1934; Power Plant Performance at the World's Largest Distillery, By W. F. Biggs, page 544, October, 1935) has two 150,000 lb. per hr., 250 lb., 500 deg. F. bent tube boilers with air heaters, forced and induced draft fans, water cooled furnaces and automatic combustion control. Pulverized coal is supplied from two 10 t. and one 3 t. pulverizers, natural gas is available as standby fuel. Feedwater is treated chemically. Electric power is generated by two 1500 kw. back pressure turbine units and the exhaust steam is used in process work. The plant is tied in with the utility system on a power interchange agreement.

The Operating Code was compiled by the Power Engineer, W. F. Biggs for the guidance of the employees primarily to promote operating efficiency, fix responsibility and prevent accidents. There are three men on duty at any one time directly responsible for the power facilities, namely, fireman, engineer and utility man.

The duties of each are enumerated and specific instructions are given in these codes for the operation of each piece of equipment under various situations. The benefits of these codes have been self-evident in that there have been no emergencies which were not properly handled by the operators nor have there been accidents or injuries to the operators.

SECTION I. GENERAL INSTRUCTIONS TO BOILER OPERATOR

Before taking over the shift, the boiler operator must proceed as follows:

1. Blow down water column and gage glass on each boiler operating and test the gages by opening gage cocks to determine water level.
2. Observe fires, rating and instruments and then, if necessary, correct fuel feed to suit operating conditions.
3. Examine gage board to see that all instruments and controls are in operation.
4. Before leaving the shift, boiler operator must report to his relief any unusual or special conditions which may exist in the equipment.
5. After taking over shift, boiler operator assumes full responsibility for further operation.
6. After assuming responsibility for the shift, boiler operator must not leave the operating floor without first notifying the operating engineer.
7. Maintain 4 to 6 in. of water in the water glass when boiler is operating.
8. Draft and fuel feed must be operated according to instructions given from time to time, or, by written instructions issued by the supervisor in charge of the boiler room.
9. Fires must be inspected to determine their condition by boiler operator from side and rear doors when instruments indicate irregularities.
10. Never blow down water walls when boiler is operating. Blow the main blow down valves at least once each 24 hours just enough each time to keep blow down valves free. Procedure in blowing down main blow down valves is as follows:
    a. Open plug cocks.
    b. Open main blow down valves slowly.
    c. Close main blow down valves slowly.
    d. Close plug cocks.
11. The boiler operator must report the following data for his shift:
    a. Number of hours boiler operates.
    b. Number of hours boiler is banked.
    c. Number of hours fans operate.
    d. Number of hours pulverizers operate.
    e. The reading of all meters at end of shift.

In the plant referred to there are two bent tube boilers burning pulverized fuel or natural gas. Each boiler has three burners, two for the main pulverizer and one for the auxiliary pulverizer. On No. 2 boiler all three are combination burners for gas or coal, while on No. 1 boiler only the auxiliary burner is of the combination type.

The power plant Operating Code of Hiram Walker & Sons, Inc., is divided into 10 sections: I. General Instructions to Boiler Operators; II. Starting Boiler on Gas; III. Changing from Gas to Pulverized Fuel; IV. Starting Boiler on Pulverized Fuel; V. Loss of Ignition; VI. Soot Blowing; VII. Shutting Down Boiler; VIII. Fires in Equipment; IX. Turbine Room Procedure; X. Starting Water Softener.

This being a pulverized fuel fired plant operating noncondensing, no reference is made to stokers or condensers. Furthermore, no code written specifically for a given plant can be applied generally without revision. Comment is therefore invited on codes for underfeed and chain grate stokers, condensers and condenser auxiliaries, refrigeration, Diesel engines and air conditioning or on any features of the above code which warrant general discussion.

For ignition purposes with gas an automatically operated pilot light arrangement is used, when the valve is opened, the gas flowing across an orifice installed in the line, operates a diaphragm switch which in turn opens an electrically operated valve in the pilot line. The pilot light, ignited by a high tension spark, remains lighted as long as gas is being burned or until shut off by hand.

Three pulverizers, two 10 t. and one 3 t. are installed and allow flexible operation. Under normal load conditions, each of the 10 t. pulverizers will supply abundant fuel for one boiler. The table type pulverizer will operate on the fluctuations in steam load while the ball mill usually carries a base load since the power consumption is nearly constant for all loads. The 3 t. pulverizer is used for week-end loads on either boiler or works in conjunction with either of the 10 t. pulverizers on heavy loads. The small pulverizer is equipped with a steam-to-air heater for mill drying of the coal. The combustion control equipment allows free manual adjustment of auxiliaries from the boiler panels.

II. STARTING BOILER ON GAS

1. Remove all danger or out of service signs placed on valves and equipment controls. Inspect all boiler setting doors to see that they are tightly closed and that the explosion doors are free.
2. See that blow down valves are closed and the boiler has at least 4 in. of water in gage glass. Open all vent valves.
3. See that all valves on pressure gages are open and gages are operating. See that water column and gage glass valves are closed.
4. Test feed valves and regulator on boiler feed line to make sure you can put water in boiler.
5. Make sure you have not overlooked anything pertaining to safety of boiler and equipment before starting fire.
6. Start preheater motor drive.
7. Open wide induced draft damper, then light torch and place in proper place to insure ignition. Slowly turn on gas and see that it ignites. There should be 4 lb. pressure on gas line. After gas ignites, adjust air to give proper combustion.
8. Adjust stack damper to maintain at least 0.10 to 0.15 in. furnace draft and slowly raise steam. Bring up to operating pressure in 1½ to 2 hr.
9. Close all vents on boiler as soon as the boiler is free of air and gas. Leave superheater valves open until boiler is cut into header.
10. Put boiler onto header. Stop valve always should be closed and drain valves between stop valve and automatic wide open to prevent water hammer. See that header line to the stop valve is free of water and the steam pressures are equal on both lines. Then slowly crack main header valve off set and when both lines have equal pressures proceed to open header valve. Next, tightly close the drain valve.

III. CHANGING FROM GAS TO PULVERIZED FUEL

A. CHANGING TO 3 T. B. & W. PULVERIZER.

1. See that induced and forced draft fans are operating at proper speeds to maintain steam pressure on gas.
2. See that coal is in bunkers.
3. See that coal scales are in operating condition.
4. Push coal burner head in proper setting.
5. See that primary fan motor and pulverizer have oil in bearings and are in operating condition.
6. Start primary air fan, put steam on air heater, and adjust air around 8 in. on primary fan.
7. Start coal pulverizer.
8. Adjust secondary air damper and induced draft fan for proper fuel-air ratio. When fire is burning, add coal as needed and reduce gas. Adjust primary air for best operating conditions.

B. CHANGING TO 10 T. B. & W. PULVERIZER.

Proceed the same as with 3 t. B&W pulverizer with the following exceptions:

1. Start pulverizer on cold air and continue for 10 min.
2. Gradually cut in hot air and at the same time shutting off cold air until you have reached the proper air temperature to dry the coal as per instructions.
3. Temperature of coal to burner must average between 140 to 150 deg. F.
4. Add burners as needed and adjust feed to meet steam demand.

C. CHANGING TO 10 T. KENNEDY-VAN SAUN PULVERIZER.

Proceed the same as with 10 t. B&W pulverizer with the following exceptions:

1. Start primary air fan first and adjust air pressure.
2. Start pulverizer. Use cold air until pulverizer is operating and then switch over to hot air. Adjust tempering air for the desired temperature.
3. Start coal feeder and adjust same for coal needed to maintain steam pressure.
4. When pulverizer is operating satisfactory, cut out gas and adjust secondary air for best operating conditions.
5. Regardless which pulverizer is operating, the air should always be adjusted to keep air flow and steam flow pens togethers.

D. PUTTING BANKED BOILER ON LINE.

1. Blow down water column and gage glass. Test the gages by opening gage cocks and see that there is not less than 3 in. of water or over 6 in.
2. Open the superheater drains wide open and allow them to remain open until the superheater is thoroughly drained and the boiler is on the line.
3. Proceed as instructed in Section II. "STARTING BOILER ON GAS" with the exception that the boiler can be forced faster because the boiler is already hot.
4. It is always best to use auxiliary feed line until boiler is operating under normal load.

This Code is divided into 10 sections; Section IV through Section X will appear in subsequent issues under the title Operating Codes for Modern Plants.

(To be continued)

Boulder Dam Finished March 1

SECRETARY OF INTERIOR Harold L. Ickes has announced that Boulder Dam and the power house would be accepted on behalf of the United States from the contractor, on March 1, thus terminating the contract and marking the end of actual construction of the project in 11 days less than five years.

More than a year prior to the date on which the project will become the property of the Government, Boulder Dam was put to work at its task of controlling the floods and conserving the waters of the Colorado River. The gates of the diversion tunnels were closed February 1, 1935, and a dangerous flood of a few months later was caught and stored.

While work continued on the project, Mead Lake, which was formed by the dam, filled to one-seventh of its capacity and grew to be the largest existing artificial body of water. In addition to catching a threatening flood, Mead Lake and Boulder Dam prevented a drought in the irrigated valleys along the lower Colorado River, where crop losses totaled $10,000,000 in 1934, by making it possible to release from storage a large volume of water than the river was carrying during the summer and fall of 1935.

Meantime preparations are being made to place the first battery of 82,500-kv-a. generators in operation in May or June. Four of these are being installed at this time. In all the power house will contain 15 generators of this size and two of 40,000-kv-a. capacity. The power house will not be fully equipped for several years.

In construction of Boulder Dam and power house, the Bureau of Reclamation estimated that a total of 604,800 man-months was provided of all classes of employment. The Bureau of Reclamation will take over the plant and equipment of the contractor for use without charge until October 1.

Laying-up Boilers

LAYING UP BOILERS is a problem that all engineers face from time to time and there is little uniformity in practice in various sections of the country, or, for that matter between different plants in the same territory. The matter is discussed in considerable detail in a recent publication, C4, of the Edison Electric Institute. Methods used by several companies may be summarized as follows:

Where boilers are not required for emergency starting and it is desired to lay them up dry, it appears to be general practice to first drop the steam pressure to atmosphere; then while still hot, drain the unit as thoroughly as possible to drive off by evaporation, through open vents or connection, all possible moisture. If superheaters or other parts are not drainable they are thoroughly blown out with air.

Trays of lime are then placed in the drums to absorb any remaining moisture and the unit is tightly closed. Before placing the lime some companies follow the blowing process with a slow dry air current and in others a slow fire is used to thoroughly dry out the interior. It is very essential that all valves between the boiler and any operating portion of the plant be tight or that the boiler be physically disconnected; otherwise excessive moisture may be admitted through leaky valves.

CHEMICALS IN WATER

Where boilers are to be made available for placing in service on short notice it is the practice to fill the unit completely and to so treat the water that it will not be corrosive. Various chemical treatments are used and it is preferable to consult a chemist to secure the best results with available water. It is usually desired that the treatment be such as to permit its use in generating steam. One company uses 200 p.p.m. tri-sodium phosphate and 200 p.p.m. potassium dichromate. Others use sodium dichromate or sodium sulphite.

One large utility company reports successful use of the following treatment for wet laying up of boilers in steam heating and electric generating plants:

A. Caustic soda is added to produce a pH value of 11.0 to the water (sampled after boiler has been filled).

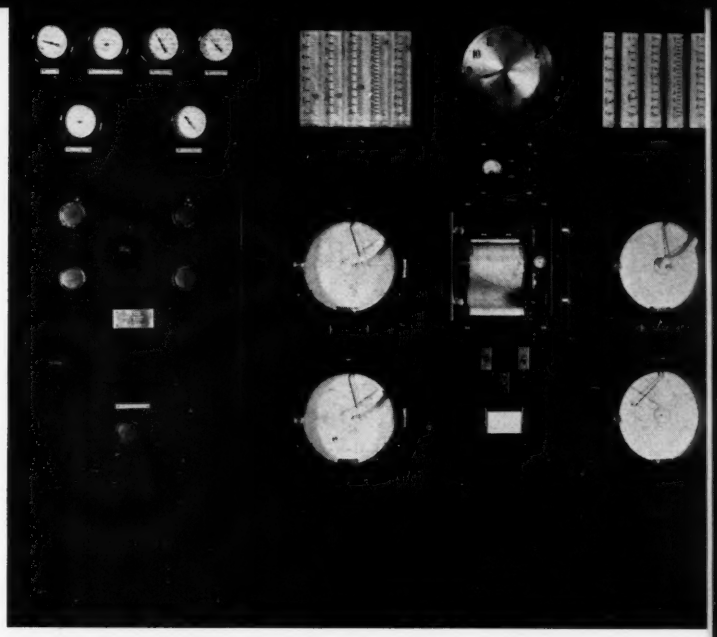
B. Sodium sulphate is added to assure required A.S.M.E. ratio. This is done to have satisfactory conditions present when the water is dropped to steaming level to go on the line.

C. Sodium sulphite is added to maintain about 30 to 40 p.p.m. present in the water when sampled after boiler has been filled.

Actual amounts of chemicals added depend on the capacity of the boiler and superheater, also on whether the boiler is being filled with deaerated water, hot water or raw water. When filling a bent-tube type boiler with an integral of two-drum economizer, where water enters at lower economizer drum, passes to the top drum and then spills down the tubes, care should be taken to have sufficient sulphite present since the sulphite-treated water cascading down the tubes picks up oxygen from the air present in the boiler.

Combustion Control

Part XIII. Air Operated System of the Hagan Corp.



COMPONENT PARTS of the Hagan control system are used in a wide variety of industrial control problems and application to boiler, or combustion control consists primarily of selecting the proper combination of elements to match the operating characteristics of the plant and give the desired degree of control. An installation may, therefore, range from a simple steam pressure control through an infinite number of combinations up to a typical modern arrangement as shown diagrammatically by Fig. 1.

This is an application of Hagan control applied to a boiler with a turbine or engine driven stoker, an individual turbine or engine driven forced draft fan and damper controlled uptake draft. For simplicity, the complete control for only one boiler is shown, but provision is made, through the Master regulator and panel, for the control of any number of boilers.

Fundamentally the system operates automatically to adjust, simultaneously and in a definite ratio, both fuel and air in accordance with the steam load and to maintain the desired furnace draft. Flexibility is built into the system by adjustments which allow the operator to change all boilers as a unit, or to adjust each boiler individually, including the air-fuel ratio, independent of the others. These adjustments are made manually at the control panels by the simple turn of a handwheel and in accordance with draft gage, CO_2 or other operating instruments installed for that purpose. Although oil is sometimes used for certain industrial applications, air at about 75 lb. pressure is the common operating medium for combustion control. In normal practice adjustments are made such that impulse pressure varies from 10 lb. at maximum boiler rating to 50 lb. at minimum rating.

This inverse relationship between boiler rating and impulse pressure is used by Hagan to guard against loss of plant load in case air pressure fails due to breakage of lines or failure of power to the compressor. In this event, ratings are gradually increased, as the pressure falls in the compressed air system, and, while safety valves may pop if the boilers are not transferred to manual control, there is no danger of dropping the load. To minimize the failure of electric power and increase reliability, a receiver is provided with sufficient

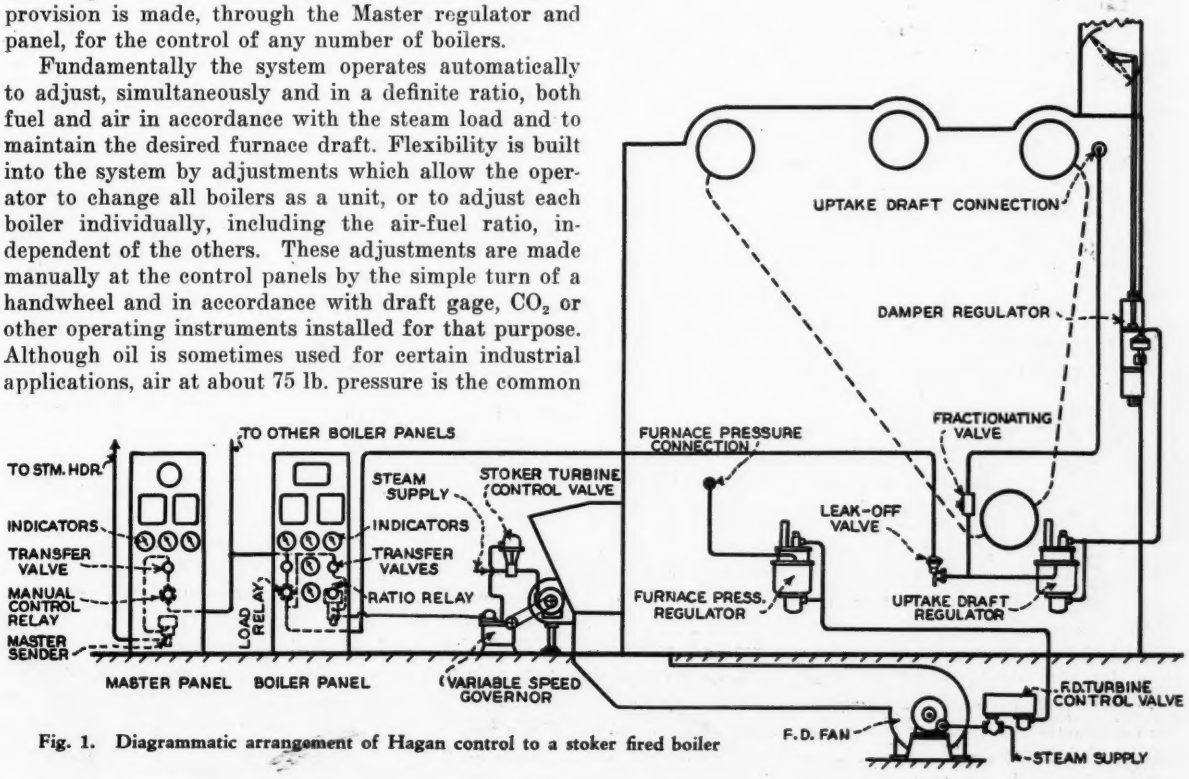


Fig. 1. Diagrammatic arrangement of Hagan control to a stoker fired boiler

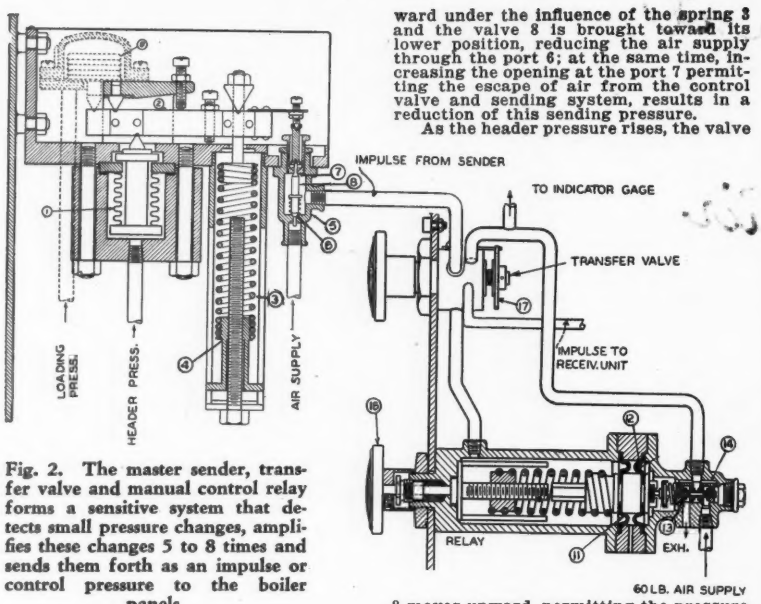


Fig. 2. The master sender, transfer valve and manual control relay forms a sensitive system that detects small pressure changes, amplifies these changes 5 to 8 times and sends them forth as an impulse or control pressure to the boiler panels

Header pressure applied on the outside of a metal bellows 1, acts upwardly on a balanced lever 2 and is opposed by a coil spring 3. The control valve 8 is attached in the balanced lever 2 through a flexible connection.

If the header pressure is lowered, the right hand end of beam 2 moves downward under the influence of the spring 3 and the valve 8 is brought toward its lower position, reducing the air supply through the port 6; at the same time, increasing the opening at the port 7 permitting the escape of air from the control valve and sending system, results in a reduction of this sending pressure.

As the header pressure rises, the valve 8 moves upward, permitting the pressure inside the valve to build up, so that the pressure in the chamber surrounding the valve and in the sending system varies directly with the header pressure and becomes the master impulse to which the entire control system responds. As the header pressure drops with increasing load these impulse pressures vary inversely as the load, i. e., maximum impulse pressure for minimum load.

Spring 3 is adjusted to balance the steam pressure at the valve it is desired to maintain, and the gradient is determined by the position of the spring nut 4. When manual adjustment of header pressure from a remote point is desired, a loading bellows 9 may be added.

The Hagan compensating or manual control relay receives the impulse pressure from the master sender or master panel and produces a second impulse pressure varying with, but not necessarily equal to, the first. Two diaphragms, 11 and 12, are placed back to back with a spacer block between them. The impulse from the sender comes through the transfer valve 17 into the spring housing and acts on the diaphragm 11 forcing it to move to the right for an increase in impulse pressure.

This opens pilot valve 13 to the air supply and allows air to flow to the sending line and through the drilled passage 14 to the space at the right of diaphragm 12. When this pressure equals the pressure acting on the diaphragm 11, the diaphragm mechanism is in equilibrium and a further slight increase in pressure on diaphragm 12 causes both diaphragms to move to the left and the pilot valve returns to the closed position.

In case a manual adjustment is desired, the handwheel 16 is used to put either a tension or compression on the coil spring. If this spring be compressed, there is a preponderance of force acting to the right and the pressure on diaphragm 12 must exceed that on diaphragm 11 by an amount dependent upon the force exerted by the spring.

For hand control the transfer valve is operated to cut off the impulse pressure from the sender and open the inside of the spring housing to atmosphere. By means of a hand-wheel 16 a pressure is then exerted on the spring which must be balanced by the pressure acting on diaphragm 12. Adjustment of the handwheel 16 therefore determines the impulse pressure that will be sent out to the boiler panels or to the receiving regulators.

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capacity to maintain the controls in full operation for a period of from 5 to 15 min. after loss of electric power or failure of plant air supply.

Referring specifically to Fig. 1, steam pressure from the header acts on the master sender and, as explained in detail in Fig. 2, generates an impulse pressure which, acting through the panel relays, controls the power elements of the system. The master sender has adjustments for varying not only the normal pressure but also incremental adjustment of the pressure gradient, i. e., maximum allowable pressure variation.

The impulse pressure developed becomes the master impulse which acts through an "automatic-manual" transfer valve and master control compensating relay to generate a sending impulse as explained by Fig. 2. The transfer valve provides a quick means for shifting from automatic to manual control and the master control relay allows manual control of all boilers as a unit. Indicating gages on the master panel show at all times the impulse generated by the master sender and the impulse transmitted by the master control relay to the individual boiler panels.

At each boiler panel the impulse passes through a second compensating or load relay, thereby making it possible to control each boiler as a separate unit. Under normal automatic control, the impulse passes through this relay, without modification, to the air flow regulators and to the second panel relay, which in turn controls the fuel feed regulators. Under these conditions each boiler will take its proportional share of the plant load.

The load relay has additional functions. By adjusting the lower handwheel it is possible to increase or decrease the effect of the impulse from the master panel, thereby setting that boiler at a higher or lower rating than the other units to throw the load to the more efficient units but still retain all boilers under full control and available for handling peak loads. Conversely, boilers with poor settings can be set below the others and, while they will take a share of the load swings, their ratings will be held below others. The transfer valve provides for manual control of each boiler at any rating where individually set. This

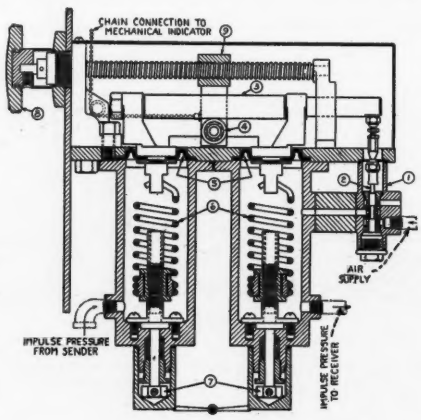


Fig. 3. The ratio relay used for maintaining the air-fuel ratio

Pilot valve 2 is actuated by beam 3 supported on fulcrum 4. This beam is subjected to opposing forces established by the two diaphragms 5 and springs 6. Tension in each spring is adjusted at 7 to equalize the force exerted by its diaphragm when subjected to full impulse pressure. The beam, therefore, balances the difference between maximum impulse and the impulse pressures under the respective diaphragms in any desired ratio depending upon the position of the adjustable fulcrum 4. As boiler rating is increased the received impulse pressure will decrease and, if fulcrum 3 is located to the right of the center position, the changes in impulse pressure transmitted by this relay will bear a fixed relation to the changes in master impulse, thereby maintaining proportional increases in fuel supplied to the boiler or furnace.

If a higher CO_2 is desired, the fulcrum 4 is shifted to the left, and the impulse pressure transmitted by the relay to the fuel regulator will be reduced, thus increasing the proportion of fuel to air. An indicator attached to the chain connection indicates the extent and direction of these adjustments.

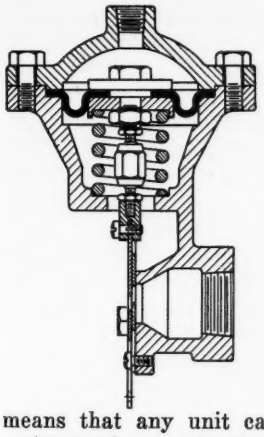


Fig. 4. A cross section of leak-off valve as used with uptake damper regulator

The valve is set so as to be closed at maximum impulse and wide open at minimum impulse. Changes in impulse allows the valve to open or close a proportionate amount and affects the action of the uptake draft on the diaphragm regulator. Adjustment of the fractionating valve, shown in Fig. 1, determines the maximum uptake draft which will be carried with the leak-off valve wide open. Closing the valve decreases and opening the valve increases

means that any unit can be operated at base load, active bank or at intermediate ratings without affecting the automatic operation of the other boilers.

The impulse from this load relay controls through the uptake draft regulator, the air supply, and also acts upon a second panel relay of the ratio or fuel type, as described in Fig. 3, for the purpose of maintaining a constant, but adjustable, fuel-air ratio at all loads. Its operation can possibly best be explained as follows: Assume the boilers, without this ratio relay, are operating at about 150 per cent rating when due to a change in the condition or quality of the fuel it becomes necessary to step up the fuel feed by some means which all control systems provide. Now assume that the load increases to 250 per cent of rating. The fuel adjustment that the operator made at 150 per cent rating is now only about half that needed and he makes a further adjustment. When the load drops he again has to make a manual correction. The relay shown by Fig. 3 was designed to overcome these constant adjustments and if the fuel-air ratio is increased, say, 5 per cent at any rating it will hold at this same increased ratio over the full range of boiler rating.

Indicators are provided on the boiler panels showing the impulse from the master panel, the load impulse sent to the boiler, the impulse to the fuel regulator and any adjustment made in the fuel-air ratio.

The impulse from the load relay might be used direct on the damper regulator shown in Fig. 7. In this case the damper would assume a definite position for each impulse value. The exact position for each impulse could be readily fixed by the profile and inclination of the compensating bar arrangement (see Fig. 7) so that any desired response characteristics could be given the regulator. Ability to adjust the response of the regulator to the characteristics of the damper makes it possible to secure satisfactory regulation with this arrangement and it is frequently used, particularly on moderate sized boilers. Its chief disadvantage is that the fuel-air ratio will be affected somewhat by changes in uptake draft due to atmospheric conditions and by the rating of other boilers discharging into the same uptake breeching or stack. While the effect of these may not be great, they may be avoided when desired by the arrangement shown in Fig. 1.

This arrangement insures that the uptake draft in the last pass, and hence the boiler output, will be graduated automatically in accordance with the impulses received from the load relay. Variations in this regulated uptake draft are secured by means of the leak-off valve (Fig. 4) and a fractionating valve located in the draft connection from the last pass.

The purpose of the leak-off valve is to open this draft connection to atmosphere in varying amounts depending upon the load impulse imposed on its diaphragm. When the leak-off valve is in the closed position (at minimum boiler load, i. e., maximum impulse pressure), the draft imposed on the diaphragm of the uptake draft regulator corresponds to the draft existing in the last pass of the boiler. The draft regulator is adjusted to this draft, which corresponds to a minimum boiler rating. As the leak-off valve gradually opens, there is a tendency for the draft under the regulator diaphragm to become more positive, which causes the regulator to open the uptake damper and increase the last pass draft by an amount sufficient to keep the draft under the regulator diaphragm at the value for which the regulator has been adjusted.

By the proper correlation of spring tension and profile of the port of the leak-off valve, the uptake draft in the last pass of the boiler can be adjusted to

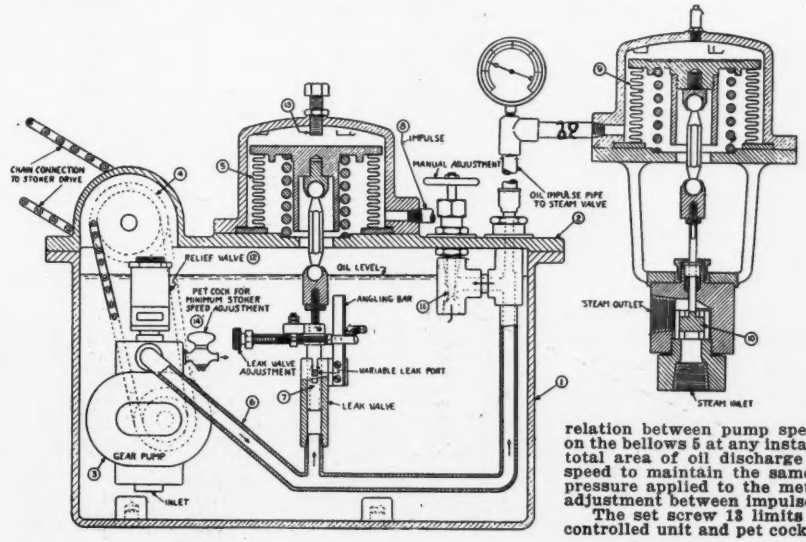


Fig. 5. Variable speed governor used for engine or turbine control

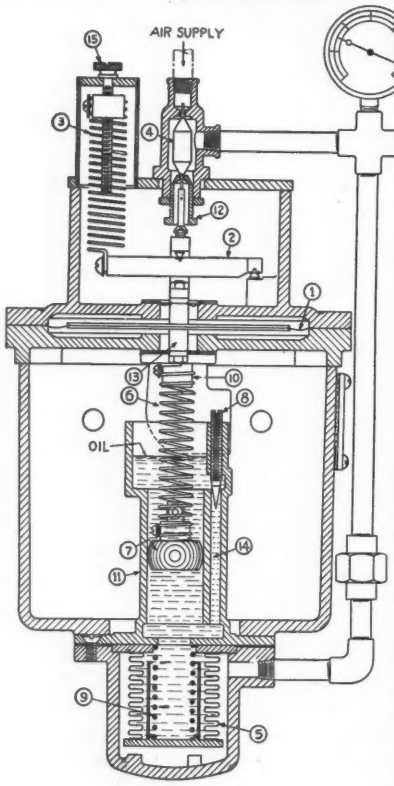
The governor consists of a rotary oil pump 3 driven by the regulated unit which thus controls the amount of oil delivered by the pump and the pressure of this oil when discharged through an orifice of fixed area. This oil pressure is applied to a bellows operated steam valve, controlling the speed of the engine or turbine, designed so that an increase in oil pressure tends to decrease the flow of steam.

The pump discharge line 6 conducts the oil under pressure to the oil leak valve 7, where it flows into the main body of oil. The port area of this leak valve 7 is controlled by metallic bellows 5, which is regulated by the impulse pressure applied through connection 8. The oil pressure generated by the pump 3 is applied to the metallic bellows 9 of the steam regulating valve 10.

Oil discharged by the pump is also permitted to leak through the manually adjusted valve 11, to provide means of adjusting the relation between pump speed and the impulse pressure imposed on the bellows 5 at any instant. Opening this valve 11 increases the total area of oil discharge ports and results in a greater pump speed to maintain the same oil pressure with the same impulse pressure applied to the metallic bellows 5. The effect is a ratio adjustment between impulse pressure and engine speed.

The set screw 13 limits the maximum regulated speed of the controlled unit and pet cock 14 the minimum regulated speed.

Fig. 6. Diaphragm regulator as used for furnace pressure and uptake draft control



A sensitive diaphragm 1 is suspended on beam 2. The regulated pressure is applied to this diaphragm (above if positive; below if negative) so that the balance beam is subjected to a downward force which is opposed by the tension of the loading spring 3 attached to the free end of the beam 2. Adjustment 15 of the spring tension determines the regulated pressure.

Movement of the diaphragm 1 operates the escapement valve 4. A downward movement of the diaphragm increases the intermediate or impulse pressure so that the impulse pressure varies incrementally with diaphragm movement.

A helical spring 6 is attached to the lower part of the diaphragm stem 13. The other end of this spring is attached to a piston 7 which can move freely in the fixed cylinder 11 which is filled with oil. This body of oil extends down into the space enclosed by the metallic bellows 5. The enclosed space surrounding this bellows is connected to the impulse pressure generated by the escapement valve 4.

An increase in impulse air pressure causes a compression of the bellows 5 which lifts the body of oil, thus raising the piston 7 to compress spring 6. Since a downward movement of the diaphragm 1 causes an increase in impulse pressure, the resulting compression of spring 6 reacts on the diaphragm to oppose any further movement downward.

The adjustable oil by-pass 14 allows oil to flow around the piston 7 so that the piston gradually returns to its normal position, thus releasing the compression (or tension) in spring 6 created by a change in impulse pressure. The time of this release is adjusted by valve 8 to suit the lag of the system to be regulated. The gradient of the compensating spring 6 and the by-pass valve 8 provide a wide adjustment in this compensating action.

any predetermined relation to the impulse received from the load relay. Generally it is so adjusted as to give a constant fuel-air ratio and thus a constant CO_2 over the full range of rating. In some cases however it is desirable to reduce somewhat the CO_2 at the higher ratings and this can be easily accomplished.

As indicated above the fuel fed to the boiler is determined by the impulse received from the ratio relay on the panel. In the case of stokers operated by variable speed d.c. motors or by variable speed drives, a fuel regulator as shown in Fig. 7 is used. This regulator will operate the rheostat or the speed changing lever of the drive to give the desired rates of fuel feed. In this application, the flexibility of adjusting the profile of the compensating bar permits building into the regulator whatever response is required by the characteristic of the rheostat or drive. Many engineers prefer steam engine or turbine drive for stokers and with these drives a variable speed governor as described in Fig. 5 is used.

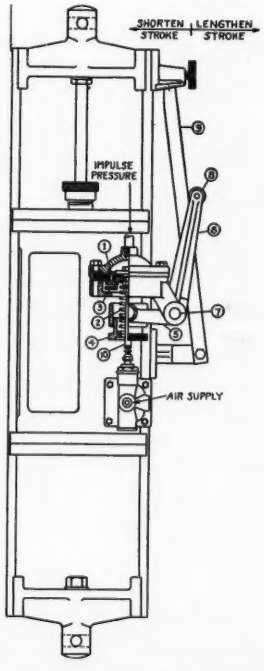
This is a rather recent development well suited to the requirements of stoker drives especially where the fluctuating load of the stoker rams has a marked tendency to interfere with engine or turbine speed. The Hagan oil relay speed governor maintains the prescribed stoker speeds over an operating speed range of 1 to 10. Engine speeds, it is claimed, can be reduced below those attainable with manual control, and speeds as low as 60 r.p.m. are regularly maintained without danger of stalling, making it possible to avoid banking boilers in many instances.

A furnace pressure regulator, as described in Fig. 6, is included to provide full control of forced draft and to maintain at all times a slight suction in the furnace. The arrangement shown in Fig. 1, controlling directly the speed of the turbine driven forced draft fan by means of a turbine control valve and without the use of dampers in the forced draft ducts, is also a relatively new development.

Elimination of these dampers on variable speed fans driven by engines or turbines was a difficult problem due to the inertia or fly wheel action which the regulator must overcome. The double compensation incorporated in the diaphragm regulator described in Fig. 6 was designed to overcome this inherent lag in the response of the fan and provide stable operation.

By controlling the supply of forced draft by a regulator responsive to furnace suction, changes in the resistance to flow through the fuel bed have no effect upon the regulation of air for combustion nor on the boiler ratings.

Fig. 7. The receiving regulator as used in Fig. 1 for operating the uptake damper



Diaphragm 1 receives the impulse pressure on the upper side while the lower side is carried on the thrust plate 3 supported by the spring 2. The lower end of the spring is carried in an adjustable socket 4 which is supported by the forked lever 5. The compensator arm 6 is rigidly connected to the lever 5 through the shaft 7 and at its upper end carries a ball bearing roller 8 which is in contact with the compensator bar 9.

The operation, starting from a minimum sending pressure with the crosshead at the bottom of its stroke, is as follows: An increase in sending pressure moves the diaphragm 1 downward. Since the socket 4 is held by the compensator mechanism, the lower end of the spring does not move and the movement of the diaphragm stops when the increased spring compression balances the increased sending pressure.

Movement of the diaphragm is transmitted through the thrust pin 10 to the pilot valve, moving it downward. This admits air to the bottom of the regulator piston which moves upward carrying the crosshead and the compensator bar 9. This action moves the roller 8 to the right and causes the left hand end of the forked lever 5 to move upwards.

This upward movement is transmitted to the socket 4 which increases the compression of the spring 2 until it returns the diaphragm 1 to its neutral position, at the same time returning the pilot valve to its closed position, to stop the movement of the piston. Each successive increase in sending pressure produces an upward movement of the crosshead. The crosshead at all times assumes a position depending upon the sending pressure.

Where a uniform or first degree relationship between impulse pressure and crosshead position is desired, the compensator bar has the form of a straight line. Where it is desired to cause the crosshead to make varying increments of stroke with equal increments of impulse pressure the compensator bar may readily be shaped to produce any desired relationship.

If it is desired to change the relation between impulse pressure and the stroke of the crosshead, the angle of the compensator bar may be adjusted by the knurled thumb screw at the top.

Ignition *and* Combustion *of* Diesel Fuels

A discussion of recent developments and tests before the annual meeting of the A.S.M.E.

By

G. D. Boerlage and J. J. Broeze

COMBUSTION PROBLEMS may be divided into phases as: introduction of the fuel; atomization; vaporization; formation of mixture; decomposition; combustion. Since the first two of these phases are mechanical problems for the designer, vaporization is the first having to do particularly with the fuel.

The importance of at least a slight vaporization of the fuel lies in the high temperature required for ignition and the short time available in high speed engines for the fuel to reach this temperature. The rate of temperature rise is far greater for fuel which is in the vapor phase than for the liquid droplets because of the more intimate contact between the fuel and the hot gases. Not more than a very slight amount of vapor is required, however, to initiate the ignition after which the heat from the combustion accelerates the vaporization of the remainder of the fuel sufficiently to meet the requirements of high-speed engines.

On the other hand, if the initial rate of vaporization is too high, its cooling effect may retard the ignition.

Volatility

An optimum volatility appears to exist for material, for instance in the successive fractions of a crude oil, the kerosene and gas oil usually igniting more readily than either the more volatile gasoline or the more paraffinic but less volatile residue. It is possible that poor ignition of the residues is also partly caused by their higher viscosities which give rise to less complete atomization.

In contrast to earlier beliefs, later calculations indicate that the beginning of ignition does not require complete vaporization of the fuel. In fact, some calculations lead to the conclusion that only a slight vaporization can occur. Although these may not be reliable because of the variety of approximations that must be made, they confirm the fact that no more than slight vaporization occurs with fuels which give satisfactory performance.

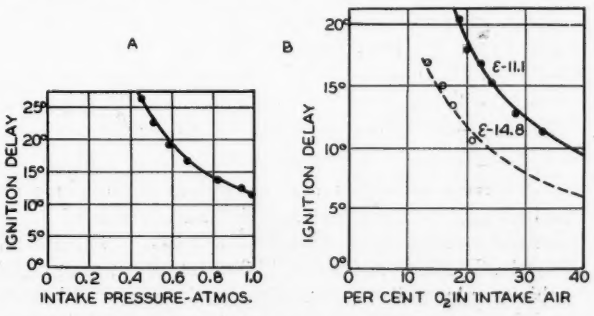


Fig. 1. A, Effect of throttling and B, concentration of oxygen on ignition delay

Mixture Distribution

Formation of sufficient vapor for ignition to start readily is not entirely a problem of fuels, for some improvement in vaporization can be made by reducing the size of the drops. This is a problem in injector design and closely allied with it is the problem of properly distributing the fuel within the combustion chamber. The significance of this problem lies in its effect on clean combustion and power output, a poorly distributed fuel mixture giving rise to smoky exhaust, after-burning with loss of power, and corrosive wear.

Common causes of poor mixture distribution are poorly placed injectors which may deposit the spray on the walls of the combustion space; obstruction of the spray by coke or leakage oil; too intensive eddying; or walls sufficiently cold to chill part of the mixture. These mixture-distribution troubles represent the major problems encountered in operating slow-speed engines on residue fuels and high-speed engines on all fuels.

Besides placing the injectors properly, the most useful tool for improving the mixture distribution is the use of turbulence, thus, in engines having a very fine atomization, the mixture tends to be over-rich around the injector, requiring either an effective air turbulence or the placing of the injector at the circumference of the combustion chamber. The flame, to some extent, promotes turbulence which can sometimes be utilized in improving the mixture distribution, though this process is not readily controlled.

Combustion Reactions

To explain the chemistry of Diesel fuel combustion, the following three theories have been advanced: 1, that the fuel reacts directly with oxygen; 2, that the fuel first forms unstable peroxides which are able to react more rapidly; 3, that the fuel is first decomposed (cracked) and the cracked products react with oxygen. In view of the disagreements between the

behavior of fuels when reacting directly with oxygen and their behavior in Diesel engines, it is concluded that direct oxidation does not occur to any important extent.

Applying the theory that the fuel first forms unstable peroxides which in turn complete the combustion, it would be expected that unsaturated compounds would ignite most readily, but this is not the case. Furthermore, while peroxides improve the ignition, substances which readily form peroxides may delay the ignition. The theory concerning peroxide formation is not necessary to explain the ready ignition of peroxides, which can be explained according to the thermal-stability theory here discussed.

Decomposition Prior to Combustion

Although the earliest investigations of the decomposition or cracking, occurring in an engine prior to ignition, led to the conclusion that complete gasification takes place, later developments indicate that the decomposition may be only partial. In support of the theory it has been shown that the products of cracking have the same spontaneous-ignition temperature, immediately after the cracking reaction, as that of the original stock which was cracked. Furthermore recent investigations show that the life of free radicals

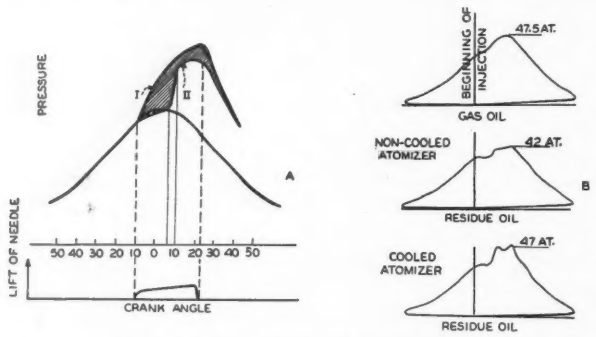


Fig. 2. A, Ideal (I) and actual (II) progress of combustion. B, Indicator diagram for gas oil and residue

formed from leadtetraethyl and -tetramethyl is of the same order of magnitude as the time of ignition in an engine.

Our investigations have led us to agree with the theory that the ignition is preceded by thermal decomposition of the fuel molecules. The thermal stability of a molecule depends mainly upon the structure and the coupling of the molecular kinetic system; thus as the bonds are branched more, the kinetic groups are coupled better so they are able to withstand greater shocks without overloading a bond. For example, in the case of tetraisobutylene and cetene, both of which have a double bond and the same chemical formula, $C_{16}H_{32}$, and about the same density, the tetraisobutylene is more compact and branched in molecular structure and has such poor ignition quality that it could only be ignited in mixtures, while cetene ignites readily.

Direct confirmation of the relation between ignition in an engine and the tendency of the fuel to decompose has been obtained by comparing the ignition value with the results of a cracking test in which various fuels were heated to 1150 deg. F. in nitrogen for a very short time. The tendency to decompose was expressed as the number of molecules formed and this result plotted against the ignition value of the base product showed a fair correlation between engine ignition and oxygenless reaction.

In addition to the activity of the fuel, the activity of the oxygen is also significant, thus as shown in Fig. 1, the concentration of air, and also the concentration of oxygen in the air, influence the ignition time. Besides the concentration, the nature of the oxygen itself affects ignition; thus the addition of active oxygen as ozone or as peroxide has a very marked effect even in very small concentrations.

Conclusion

Pressure diagrams show that, following the injection of fuel into an engine, there is a delay prior to the main pressure rise. This delay has been described as a warming-up period during which the temperature of the fuel is approaching that required for a flame to start. However, closer inspection of the diagram indicates that not only does the pressure often decrease at first suggesting the absorption of heat resulting possibly from vaporization or decomposition, but that it may then increase by as much as several atmospheres before the rapid combustion sets in. We prefer, therefore, to conceive of the delay time as an active period during which reactions occur which develop heat. As soon as the temperature at some point becomes sufficiently high the flame starts, which has been found to follow the laws of flame combustion, e.g., acceleration by whirling.

This second period is one of uncontrolled combustion and is followed by a third period during which the combustion is controlled by the rate of fuel injection. With slow-speed engines in which the delay period is short compared with the total time of fuel injection, the combustion curve has a smooth character, however, with high-speed engines, the first and second periods become more distinct.

In general, the efficiency and power of an engine depend primarily on the ignition delay of the fuel and the completeness with which it is distributed within the combustion space. The latter is chiefly a design problem; the former is dependent upon the type and treatment of the fuel. While poor fuels can be improved by mixture with dopes such as peroxides or nitrates, such treatment is expensive and can generally be dispensed with if the fuel is prepared from selected crudes. Since these crudes are in general the ones which are least desirable for the manufacture of gasoline, the expansion of the use of Diesel engines really need not produce a serious drain on the available supplies of fuels for gasoline engines.

Electric Hot-beds are no longer an experiment and give a temperature control far more reliable than Nature ever permits. The Federal Relief Farm near Seattle, Wash., produced 715,000 lettuce, tomato and cabbage plants last year. Heating began in February and in five months 14,700 kw-hr. were used. That is forty-eight plants for each kilowatt-hour of electricity.

Electron Tubes — Principles *and* Applications

Part II. Further considerations regarding the flow of electrons in conductors. The mechanism of the thermionic effect. Increasing industrial application of electron devices. By A. W. Kramer

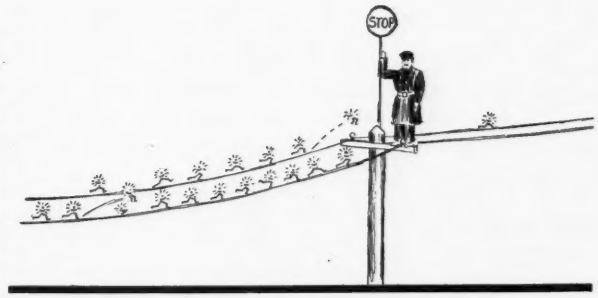
SINCE AN ELECTRIC CURRENT is in reality a flow or drift of electrons through a conductor and since this flow may be maintained by an electric generator or battery, we may ask how can such a flow of electrons be stopped. Of course the generator can be stopped and that would stop the flow of electrons in the same way that the flow of water through a system is stopped when the pump is stopped. Assuming, however, that the generator continues in operation, how can the flow be stopped? In the case of the hydraulic system the mere closing of a valve in the line is sufficient to stop the flow. As the valve closes the area through which the water flows is gradually restricted allowing less water to pass and finally when the valve is completely closed the flow is stopped entirely.

The electrical condition is somewhat similar. Here also it is necessary to interpose some sort of a barrier in the line through which the free electrons cannot pass. All that is necessary is to place an insulating material in the circuit at some point. The easiest way to do this is to break the circuit at some point and pull the ends far enough away from each other so as to interpose a certain amount of air between them. For air, at atmospheric pressure, is a good insulator and since it instantly flows into the break it effectively stops the flow of electrons, and the full electrical pressure (voltage) which caused the flow appears between the free ends vainly trying to re-establish the flow. Such an arrangement is provided by an ordinary knife switch in air.

Here again it is extremely fortunate that the atmosphere in which we live does not contain many free electrons under normal conditions. For if it did we would not be able to break even the weakest electric current by opening a switch in air. As it is, there are enough free electrons in air to make the action difficult where very high voltages are used.

At ordinary voltages, say below 500 or 600 v., an "air break" switch operates effectively but at high voltages difficulties arise; the current tends to flow even after the conductor is broken. An arc appears at the break. Often this arc must be drawn out to an appreciable length before the current is interrupted.

We shall not attempt, here, to explain the nature of this arc or how it is formed, for, as implied before,



HOW CAN WE STOP THIS FLOW OF ELECTRONS ?

it is a complicated phenomena[1] and is not essential to an understanding of the vacuum tube. The fact that an arc of this kind forms, however, seems to indicate that under certain conditions at least electrons may flow through a gas, for air may be regarded as a gas at ordinary temperatures.

Apparently then under certain conditions free electrons have the power of leaving the metals in which they normally exist, and passing out into materials which ordinarily are classed as non-conductors or insulators. In Fig. 1 is shown the simplest form of lightning arrestor. It consists simply of a gap—a spark gap—one side of which is attached to the power or telephone line and the other side is connected to the ground. Normally, the voltage on the line is insufficient to force electrons out of the conductor into the air gap but when lightning strikes the line, the voltage rises to such a high value that the air gap breaks down and the current flows across the air space to the ground. As the lightning surge expends itself in this manner, the voltage decreases until finally it can no longer keep the electrons out in space and they scamper back into the conductor and so terminate the flow. Thus, an air gap of this kind acts just as a safety valve on a boiler.

Years ago it was discovered that if two terminals were sealed into the ends of a glass tube and the tube exhausted of air, an electric current could be made to pass across the space inside. This required rela-

[1]Theory of the Electric Arc, Slepian, Journal of the Western Society of Eng., April, 1928. The Electric Arc, K. T. Compton, A.I.E.E. Transactions, 1927. Temperature of a Contact, page 930, Journal of the A.I.E.E., October, 1926. Vacuum Switching Experiments, A.I.E.E. Transactions, 1926, p. 1102. Using Gas for Arc Rupture in Circuit Breakers, Power Plant Engineering, March 1, 1930, p. 282. Part II March 15, 1930, p. 345.

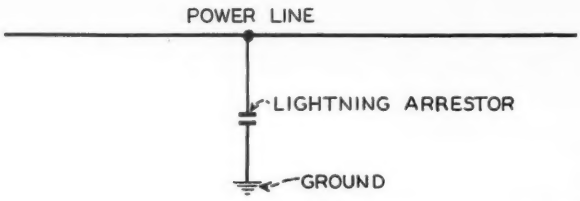


Fig. 1. Simplest type of lightning arrestor which acts as a kind of a safety valve for relieving excess electrical pressure

tively high voltages but, as in the case of the spark gap, it also showed that electrons could leave the metal terminals and pass across a space occupied only by very rarified air.

These were our first vacuum tubes, at least they were called that. They were really not vacuum tubes because they still contained appreciable quantities of gas.[2] Under certain conditions they would glow with beautiful colors but they were little more than curious playthings and of no earthly use. It was realized that something curious was going on inside these tubes but few realized that they contained the embryo of the most amazing discoveries of the next half century.

Electric current flows through such tubes in either direction, the polarity of the terminals making no difference. The current, furthermore, is very small, even with voltages as high as fifty and one hundred thousand volts, but the fact that current flows at all is quite remarkable—at least it was considered remarkable at the time these effects were first noticed. At that time the electron theory of electricity had not been established and there was no logical theory available to account for it.

In these early days there was noticed another phenomenon which attracted attention but which could not be explained. This was a discovery made by Edison about 50 yr. ago, also long before anybody knew anything about electrons. In developing the incandescent lamp Edison noticed a curious phenomenon which occurred when he placed a small metal plate in the bulb of a lamp as shown in Fig. 3. When the filament was heated to incandescence, Edison found that the plate became charged electrically and if it was connected through a sensitive galvanometer to the positive terminal of the filament, a current would flow. When the plate was connected to the negative terminal, however, no current would flow. Apparently, the presence of the hot filament in some mysterious way contributed to produce a charge on the plate.

That hot bodies produced electrical effects had been known before; indeed for a hundred years it had been known that when a metal is brought to a state of incandescence, the air in its immediate vicinity becomes a conductor of electricity, but this still did not explain the "Edison effect" as it was called and for a long time it remained a mystery. For a time it was more or less forgotten.

In time, however, more became known about the nature of electricity and the electron theory was evolved. This for the first time gave us a clue regarding the mechanism of electric conduction and also offered an explanation of the Edison effect. For according to the electron theory, it was quite possible that when a metal was heated to a high temperature as in the case of a filament, electrons might be "boiled" out of the metal, so to speak, and projected out into space, just as molecules of water are projected out of the surface of a vessel of boiling water.

This is actually the case. Electrons *are* "boiled" out of hot metals in very much the same way that water is evaporated when raised to the boiling point.

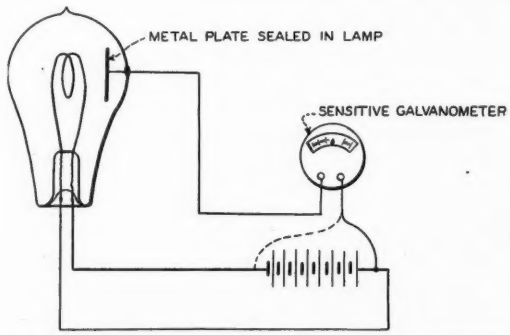


Fig. 3. Edison noticed a curious phenomenon when he placed a small metal plate in the bulb of a lamp. When the filament was heated, the plate became charged electrically and if it was connected through a sensitive galvanometer to the positive terminal of the filament, current would flow

The process of evaporation of liquids is due to thermal agitation of the liquid molecules. As heat is applied to a vessel of water, the velocities of the molecules increase and the frequency of collision between the molecular systems also increases. Due to the severe impact of collisions certain of the molecules attain velocities much greater than the average. If the molecules which have just acquired velocities greater than the average happen to be near the surface of the liquid, they may overcome the surface tension of the liquid (which normally prevents their escape) and be projected out into the atmosphere above the surface of the liquid. Thus they become gas or vapor molecules.

As the temperature of the liquid is raised, the average velocity of the molecules becomes greater and more molecules attain velocities great enough to carry them out of the liquid.

In metals, at high temperatures, a similar process occurs, the molecular activity of both the atoms and free electrons is greatly increased and certain of the free electrons acquire sufficient velocity to enable them to overcome the restraining force at the surface and they are thus projected out into space. As early as 1899 J. J. Thomson had shown that negative electricity was given off from the hot filament of Edison's lamp in the form of electrons but the mechanism of this emission was not known until O. W. Richardson in

[2]No tube referred to as a vacuum tube is really a true vacuum tube because even after such a tube has been exhausted by the most refined methods known to science, it still contains countless millions of atoms of gas.

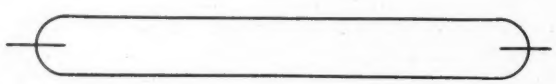


Fig. 2. Years ago it was discovered that if two terminals were sealed into the ends of a glass tube and the tube exhausted, an electric current would be made to pass across the space inside

1901 showed that the electrons are emitted solely by virtue of their kinetic energy.

At ordinary temperatures very few electrons in the more common metals possess sufficient kinetic energy to overcome the surface tension at the boundaries of the body and the number of electrons escaping at such temperatures is negligibly small. At any particular moment some electrons will have zero velocity while others will have extremely high velocities. The majority, however, will have velocities ranging between the two extreme values of speed. It is only those few electrons with the extremely high velocities that are able to escape through the surface.

We must not confuse this process of electron evaporation with the evaporation or rather the vaporization of metals. The evaporation of electrons occurs at a lower temperature than that at which evaporation of atoms occurs. This is due to the fact that the average velocity of the electron is much higher than that of the atom. We would, therefore, expect to obtain a copious emission of electrons at a temperature considerably below the boiling point of the metal and this actually is the case. Figure 4 shows how the electron emission from tungsten varies with temperature.

Now that we have explained the manner in which electrons are emitted from metals, we can begin a detailed consideration of the electron or thermionic tube. For this process of "boiling" electrons out of metals is known as the thermionic effect—that is it is the production of "ions" by "thermal" agitation. Electrons (ions) can be released from metals in other ways also, i.e., by merely pulling them out by means of extremely high potentials, but the thermionic method is by far the simplest and results in the release of the greatest number. This phenomena, which was regarded at first merely as an interesting fact, is responsible for perhaps the most startling developments in the realm of electricity—indeed it is the foundation of the whole modern art of electrical communication. Without electron emission from hot filaments there would be no thermionic tubes and without thermionic tubes there would be no radio broadcasting and receiving, or telegraph and picture transmission as we know it today. Nor would there be countless electrical control devices in industry which we have today. The photo electric cell which is used widely in industry does not use it, but the photo electric cell would be useless except for the thermionic tube amplifier which *does* use it.

It is true, the thermionic tube is not absolutely essential to the production of radio waves, but it *is* essential in the construction of modern radio receivers using loud speakers and its use has so simplified the production of radio waves that its advent has revolutionized the whole art of radio and wire communication. Without it, transcontinental telephony would be impossible.

And now the electron tube is finding its way into industry. For a number of years tubes have been used in various control applications and wherever it has been used it has improved operation. In conjunction with the photocell (which, of course, is also an electron tube) it has made possible operations which could not be accomplished in other ways. For countless purposes, from counting and sorting oranges and cigars

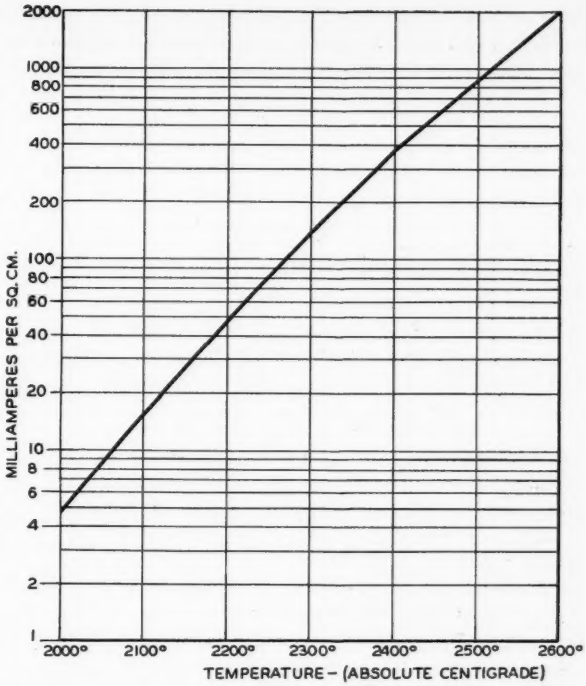


Fig. 4. Graph showing how the electron emission from tungsten varies with the absolute temperature. In this case the electron emission is given in milliamperes. Since one milliampere is equal to 6,280,000,000,000,000 electrons the total number of electrons emitted per sq. cm. can be arrived at by merely multiplying by this factor

to the control of reversing rolling mills and from the analysis of color in textile mills to the control of electric welding operation in steel plants, the electron tube has met with constantly increasing success. The future, however, points to far greater achievements. As a heavy power device in the transmission and distribution of power it will undoubtedly find its most spectacular applications.

Tubes for Engine

Recently, in a large industrial power plant, an entire 25 cycle engine driven generator was replaced by a 300 kw. bank of grid-controlled electron tubes which converts 60 cycle power into 25 cycle power. At present the tubes are used only for this purpose—frequency conversion. In making this installation it was necessary to take into account the fact that future plans called for the gradual elimination of the 25 cycle system and also that a limited amount of direct current is needed at this plant. Thus, in time, a portion of the control equipment will be disconnected and the same tubes which now serve as a converter will then serve as a rectifier with a d.c. output of 300 kw. at 350 v.

This installation is cited merely as an example of what is coming. Already electron tubes are in commercial service as voltage regulators and exciters for synchronous machines as large as 15,000 kw. and they form an integral part of modern welding equipment. Tubes of 1000 kw. capacity have been built and a 400 hp. motor controlled by electron tubes has been installed in a power plant for forced draft service.

It is true, of course, that tubes have been available for use in industry for a number of years and it may seem that their application has not been as rapid as was first predicted. This slow growth was due to a number of factors. To begin with, the electron tube was born of the radio industry, indeed, it is at once the child and father of that industry. This gave it an element of mystery which practical engineers were afraid to approach—it imposed mental barriers which retarded its acceptance. Next, there was its fragility, the fact that it was made of glass and that it was delicate and easily damaged. Also, there were its limitation with respect to power handling capacity.

A further factor which retarded the rate of industrial application of electronic devices was the general lack of understanding of how the devices work, what rules must be observed when they are built into a machine in which they control some function and of how to service them. This condition still prevails generally but as the number of electronic devices has increased a number of the more progressive plant engineers have undertaken the study of electron tubes and their circuits and have found that, for their uses, the operation of a particular electronic circuit is as readily understandable as a magnetic control circuit of comparable complexity.

For the Average Man

As is obvious, none of the barriers or limitations which retarded the more rapid growth of industrial electronic applications were of a fundamental nature which could not be overcome. Indeed, despite the retarding influences there has been a healthy growth in the use of electron devices of all kinds. Tube construction has grown more rugged, power handling capacities have been increased and now, with the advent of mass production of all-metal tubes the question of fragility is no longer valid. Electron tubes today are quite as rugged as most other electrical equipment.

It is because of this accelerating rate of application of electronic devices in industry that we present this series of articles. Our aim will be to make them as simple as possible consistent with accuracy. They are written with the average power plant man in mind and presuppose no previous knowledge of electron tube theory except that which has been presented in these first two articles.

Reports from the American Consulate-general, Frankfort-On-Main, made public by the Department of Commerce, show that the Diesel engine is making advances in German industry rivaling advances in this country. The 1933 National Census showed 30,000 engines with a total horsepower of 1,200,000 installed in 25,000 plants. This compares with a total horsepower of 633,000, 11,600 engines in 10,000 plants reported in the 1925 census.

Numerically, the precentage of prime movers, represented by oil engines, increased from 6.7 per cent in 1925 to 18 per cent in 1933, although measured in horsepower, these figures were but 2.8 and 4.3 per cent, respectively, indicating a large increase in the smaller engines and a decline of the average horsepower from 50 in 1925 to 40 in 1933.

Lighting Savings in Power Plants

By S. H. Coleman

POSSIBLE savings to be secured by proper lighting and lighting control are often overlooked by engineers responsible for power plant operation. This lack of interest is, no doubt, due to the impression that economy in power plant illumination is another case of "Carrying coals to Newcastle." While adequate lighting is at all times desirable and necessary, wasteful illumination increases station service power consumption, with a resulting increase in the cost per net kilowatt leaving the plant.

A comprehensive lighting survey, making use of instruments to determine light intensity, will reveal all cases of excessive or inadequate illumination. Where excessive illumination is discovered, correction will mean a direct saving. Cases of inadequate illumination, however, are often subject to correction, with no appreciable increase in wattage consumption. Where extensive external lighting is provided as an advertising medium, or for protective purposes, an increased field for economy exists.

Among the factors contributing to wasteful lighting are; poor design, improper control, and indifference toward proper maintenance. Any one, or all, of these factors will cause an increased wattage consumption for a given lighting intensity, and incidentally add appreciably to the cost of lamp renewals.

Proper lighting system design involves the selection and placement of the right fixtures to insure the right intensity of lighting in the area illuminated. The wrong fixture, or an improperly located fixture, will require a higher wattage lamp, with its attendant waste. Circuits should be so segregated that infrequently used fixtures, or groups of fixtures, can be independently controlled. Control switches for all circuits should be placed at logical and accessible points.

The prevention of waste caused by improper lighting control is one of the responsibilities of the operating crew. Lights burning when not needed are a major source of controllable waste. Attention given to this one point will often effect substantial savings. Where extensive external lighting systems are to be controlled, automatic control devices will eliminate the human factor by automatically controlling illumination as required by daylight intensity or by predetermined time settings.

Careful maintenance is essential if maximum lighting system efficiency is desired. Substitution of lamps larger than necessary, or having voltage ratings different from the circuit voltage, must be guarded against when making lamp renewals. Periodic cleaning of lamps and reflectors will often be the means of reducing lamp sizes. Vibration of fixtures should be eliminated wherever found, if frequent lamp renewals are to be avoided. Circuit voltages should be checked and maintained as closely as possible to the rated voltage of the installed lamps if frequent lamp renewals or inefficient illumination are to be prevented.

Table of Saturated Steam Temperatures

By FRED J. WIEGAND*

ONE OF the most frequent uses made of a steam table is to find the saturation temperature of steam at a given pressure. Most tables give this temperature for every pound of pressure below 200 lb. per sq. in. absolute. Above this pressure, however, the ordinary tables require interpolation as the values are given only in increments of 5 or 10 lb. pressure. For this reason, and because most power pressures are above 200 lb. per sq. in. absolute, I have compiled the accompanying table from which saturation temperatures can be read directly. In some cases, the values of pressures are taken to the first decimal place. Hence I have included tabulations of proportional parts (P.P.), although for most practical purposes these are unnecessary.

For close calculation, however, these proportional parts might be used as follows: Supposing a pressure (absolute) of 267.7 lb. per sq. in. is given and it is desired to find the temperature. Opposite the pressure 267 the temperature is given as 406.79 deg. F., to this must be added the proportional part represented by 0.7 of a degree, so reference is made to the first division of the column headed proportional parts, in the section between 260 and 269 lb. where the decimal 0.7 appears and opposite it the value in degrees Fahrenheit, 0.24. Add this to 406.79 and the answer is 407.03 deg. F. If the given pressure were 267.4 deg. F., the answer would have been 406.79 + 0.13 = 406.92 deg. F.

These proportional parts have been worked out in groups, each group based on the average variation over a 10-lb. range of pressure.

The values are based on the Steam Tables of Joseph H. Keenan, published by the A.S.M.E.

*Senior Calculator, U. S. Naval Boiler Laboratory.

LB. PER SQ.IN.	DEG.F.	P.P.		LB. PER SQ.IN.	DEG.F	P.P.		LB. PER SQ.IN.	DEG.F.	P.P.		LB. PER SQ.IN.	DEG.F.	P.P.	
200	381.82			300	417.33			400	444.58			500	466.99		
201	382.23	.1	.04	301	417.63	.1	.03	401	444.82	.1	.02	501	467.19	.1	.02
202	382.65	.2	.08	302	417.93	.2	.06	402	445.06	.2	.05	502	467.40	.2	.04
203	383.06	.3	.12	303	418.24	.3	.09	403	445.31	.3	.07	503	467.60	.3	.06
204	383.48	.4	.16	304	418.54	.4	.12	404	445.55	.4	.10	504	467.80	.4	.08
205	383.89	.5	.21	305	418.84	.5	.15	405	445.79	.5	.12	505	468.01	.5	.10
206	384.30	.6	.25	306	419.14	.6	.18	406	446.03	.6	.15	506	468.21	.6	.12
207	384.71	.7	.29	307	419.44	.7	.21	407	446.27	.7	.17	507	468.41	.7	.14
208	385.11	.8	.33	308	419.75	.8	.24	408	446.52	.8	.19	508	468.61	.8	.16
209	385.52	.9	.37	309	420.05	.9	.27	409	446.76	.9	.22	509	468.82	.9	.18
210	385.93			310	420.35			410	447.00			510	469.02		
211	386.33	.1	.04	311	420.64	.1	.03	411	447.24	.1	.02	511	469.22	.1	.02
212	386.73	.2	.08	312	420.94	.2	.06	412	447.48	.2	.05	512	469.43	.2	.04
213	387.13	.3	.12	313	421.23	.3	.09	413	447.71	.3	.07	513	469.63	.3	.06
214	387.53	.4	.16	314	421.53	.4	.12	414	447.95	.4	.10	514	469.83	.4	.08
215	387.93	.5	.20	315	421.82	.5	.15	415	448.19	.5	.12	515	470.04	.5	.10
216	388.32	.6	.24	316	422.11	.6	.18	416	448.43	.6	.14	516	470.24	.6	.12
217	388.71	.7	.28	317	422.41	.7	.21	417	448.67	.7	.17	517	470.44	.7	.14
218	389.11	.8	.32	318	422.70	.8	.24	418	448.90	.8	.19	518	470.64	.8	.16
219	389.50	.9	.36	319	423.00	.9	.26	419	449.14	.9	.21	519	470.85	.9	.18
220	389.89			320	423.29			420	449.38			520	471.05		
221	390.27	.1	.04	321	423.58	.1	.03	421	449.61	.1	.02	521	471.25	.1	.02
222	390.66	.2	.08	322	423.86	.2	.06	422	449.85	.2	.05	522	471.44	.2	.04
223	391.04	.3	.11	323	424.15	.3	.09	423	450.09	.3	.07	523	471.64	.3	.06
224	391.43	.4	.15	324	424.44	.4	.11	424	450.32	.4	.09	524	471.84	.4	.08
225	391.81	.5	.19	325	424.73	.5	.14	425	450.55	.5	.12	525	472.04	.5	.10
226	392.19	.6	.23	326	425.01	.6	.17	426	450.78	.6	.14	526	472.23	.6	.12
227	392.57	.7	.27	327	425.30	.7	.20	427	451.02	.7	.16	527	472.43	.7	.14
228	392.94	.8	.30	328	425.59	.8	.23	428	451.25	.8	.19	528	472.63	.8	.16
229	393.32	.9	.34	329	425.87	.9	.26	429	451.49	.9	.21	529	472.82	.9	.18
230	393.70			330	426.16			430	451.72			530	473.02		
231	394.07	.1	.04	331	426.44	.1	.03	431	451.95	.1	.02	531	473.22	.1	.02
232	394.44	.2	.07	332	426.72	.2	.05	432	452.18	.2	.05	532	473.41	.2	.04
233	394.81	.3	.11	333	427.00	.3	.08	433	452.41	.3	.07	533	473.61	.3	.06
234	395.18	.4	.15	334	427.28	.4	.11	434	452.64	.4	.09	534	473.81	.4	.08
235	395.56	.5	.19	335	427.56	.5	.14	435	452.87	.5	.11	535	474.01	.5	.10
236	395.92	.6	.22	336	427.84	.6	.17	436	453.09	.6	.14	536	474.20	.6	.12
237	396.29	.7	.26	337	428.12	.7	.20	437	453.32	.7	.16	537	474.40	.7	.14
238	396.66	.8	.30	338	428.40	.8	.22	438	453.55	.8	.18	538	474.60	.8	.16
239	397.03	.9	.33	339	428.68	.9	.25	439	453.78	.9	.21	539	474.79	.9	.18
240	397.40			340	428.96			440	454.01			540	474.99		
241	397.76	.1	.04	341	429.24	.1	.03	441	454.24	.1	.02	541	475.18	.1	.02
242	398.11	.2	.07	342	429.51	.2	.06	442	454.46	.2	.05	542	475.37	.2	.04
243	398.47	.3	.11	343	429.79	.3	.08	443	454.69	.3	.07	543	475.56	.3	.06
244	398.83	.4	.14	344	430.06	.4	.11	444	454.91	.4	.09	544	475.76	.4	.08
245	399.20	.5	.18	345	430.34	.5	.14	445	455.14	.5	.11	545	475.95	.5	.10
246	399.54	.6	.21	346	430.61	.6	.17	446	455.37	.6	.14	546	476.14	.6	.11
247	399.90	.7	.25	347	430.89	.7	.19	447	455.59	.7	.16	547	476.33	.7	.13
248	400.26	.8	.29	348	431.16	.8	.22	448	455.82	.8	.18	548	476.52	.8	.15
249	400.61	.9	.32	349	431.44	.9	.25	449	456.04	.9	.20	549	476.71	.9	.17
250	400.97			350	431.71			450	456.27			550	476.91		
251	401.32	.1	.03	351	431.98	.1	.03	451	456.49	.1	.02	551	477.10	.1	.02
252	401.67	.2	.07	352	432.25	.2	.05	452	456.71	.2	.04	552	477.29	.2	.04
253	402.01	.3	.10	353	432.51	.3	.08	453	456.93	.3	.07	553	477.48	.3	.06
254	402.36	.4	.14	354	432.78	.4	.11	454	457.15	.4	.09	554	477.67	.4	.08
255	402.71	.5	.17	355	433.05	.5	.13	455	457.38	.5	.11	555	477.86	.5	.10
256	403.05	.6	.21	356	433.32	.6	.16	456	457.60	.6	.13	556	478.05	.6	.11
257	403.40	.7	.24	357	433.59	.7	.19	457	457.82	.7	.15	557	478.25	.7	.13
258	403.74	.8	.28	358	433.85	.8	.21	458	458.04	.8	.18	558	478.44	.8	.15
259	404.09	.9	.31	359	434.12	.9	.24	459	458.26	.9	.20	559	478.63	.9	.17
260	404.43			360	434.39			460	458.48			560	478.82		
261	404.77	.1	.03	361	434.65	.1	.03	461	458.70	.1	.02	561	479.01	.1	.02
262	405.11	.2	.07	362	434.91	.2	.05	462	458.92	.2	.04	562	479.19	.2	.04
263	405.44	.3	.10	363	435.18	.3	.08	463	459.13	.3	.07	563	479.38	.3	.06
264	405.78	.4	.13	364	435.44	.4	.10	464	459.35	.4	.09	564	479.57	.4	.07
265	406.12	.5	.17	365	435.70	.5	.13	465	459.57	.5	.11	565	479.75	.5	.09
266	406.45	.6	.20	366	435.96	.6	.16	466	459.79	.6	.13	566	479.94	.6	.11
267	406.79	.7	.24	367	436.22	.7	.18	467	460.01	.7	.15	567	480.13	.7	.13
268	407.13	.8	.27	368	436.49	.8	.21	468	460.22	.8	.18	568	480.31	.8	.15
269	407.46	.9	.30	369	436.75	.9	.24	469	460.44	.9	.20	569	480.50	.9	.17
270	407.79			370	437.01			470	460.66			570	480.69		
271	408.12	.1	.03	371	437.27	.1	.03	471	460.87	.1	.02	571	480.87	.1	.02
272	408.45	.2	.07	372	437.53	.2	.05	472	461.09	.2	.04	572	481.06	.2	.04
273	408.78	.3	.10	373	437.78	.3	.08	473	461.30	.3	.06	573	481.24	.3	.06
274	409.11	.4	.13	374	438.04	.4	.10	474	461.52	.4	.09	574	481.43	.4	.07
275	409.44	.5	.16	375	438.30	.5	.13	475	461.73	.5	.11	575	481.62	.5	.09
276	409.76	.6	.20	376	438.56	.6	.15	476	461.94	.6	.13	576	481.80	.6	.11
277	410.09	.7	.23	377	438.82	.7	.18	477	462.16	.7	.15	577	481.99	.7	.13
278	410.41	.8	.26	378	439.07	.8	.21	478	462.37	.8	.17	578	482.18	.8	.15
279	410.74	.9	.29	379	439.33	.9	.23	479	462.59	.9	.19	579	482.36	.9	.17
280	411.06			380	439.59			480	462.80			580	482.55		
281	411.38	.1	.03	381	439.84	.1	.03	481	463.01	.1	.02	581	482.73	.1	.02
282	411.70	.2	.06	382	440.09	.2	.05	482	463.22	.2	.04	582	482.91	.2	.04
283	412.02	.3	.10	383	440.35	.3	.08	483	463.43	.3	.06	583	483.09	.3	.05
284	412.34	.4	.13	384	440.60	.4	.10	484	463.64	.4	.08	584	483.27	.4	.07
285	412.66	.5	.16	385	440.85	.5	.13	485	463.86	.5	.11	585	483.46	.5	.09
286	412.98	.6	.19	386	441.10	.6	.15	486	464.07	.6	.13	586	483.64	.6	.11
287	413.29	.7	.22	387	441.35	.7	.18	487	464.28	.7	.15	587	483.82	.7	.13
288	413.61	.8	.25	388	441.61	.8	.20	488	464.49	.8	.17	588	484.00	.8	.14
289	413.92	.9	.29	389	441.86	.9	.23	489	464.70	.9	.19	589	484.18	.9	.16
290	414.24			390	442.11			490	464.91			590	484.36		
291	414.55	.1	.03	391	442.36	.1	.03	491	465.12	.1	.02	591	484.54	.1	.02
292	414.86	.2	.06	392	442.60	.2	.05	492	465.33	.2	.04	592	484.72	.2	.04
293	415.18	.3	.09	393	442.85	.3	.07	493	465.53	.3	.06	593	484.90	.3	.05
294	415.49	.4	.12	394	443.10	.4	.10	494	465.74	.4	.08	594	485.08	.4	.07
295	415.80	.5	.16	395	443.35	.5	.12	495	465.95	.5	.10	595	485.27	.5	.09
296	416.11	.6	.19	396	443.59	.6	.15	496	466.16	.6	.12	596	485.45	.6	.11
297	416.41	.7	.22	397	443.84	.7	.17	497	466.37	.7	.15	597	485.63	.7	.13
298	416.72	.8	.25	398	444.09	.8	.20	498	466.57	.8	.17	598	485.81	.8	.14
299	417.02	.9	.28	399	444.33	.9	.22	499	466.78	.9	.19	599	485.99	.9	.16

LB. PER SQ.IN.	DEG.F	P.P.		LB. PER SQ.IN.	DEG.F.	P.P.		LB. PER SQ.IN.	DEG.F	P.P.		LB. PER SQ.IN.	DEG.F.	P.P.	
600	486.17			650	494.85			700	503.04			750	510.79		
601	486.35	.1	.02	651	495.01	.1	.02	701	503.20	.1	.02	751	510.94	.1	.02
602	486.52	.2	.04	652	495.18	.2	.03	702	503.36	.2	.03	752	511.09	.2	.03
603	486.70	.3	.05	653	495.35	.3	.05	703	503.51	.3	.05	753	511.24	.3	.05
604	486.88	.4	.07	654	495.52	.4	.07	704	503.67	.4	.06	754	511.39	.4	.06
605	487.06	.5	.09	655	495.69	.5	.08	705	503.83	.5	.08	755	511.55	.5	.08
606	487.23	.6	.11	656	495.86	.6	.10	706	503.99	.6	.09	756	511.70	.6	.09
607	487.41	.7	.13	657	496.02	.7	.12	707	504.14	.7	.11	757	511.85	.7	.11
608	487.59	.8	.14	658	496.19	.8	.13	708	504.30	.8	.13	758	512.00	.8	.12
609	487.76	.9	.16	659	496.36	.9	.15	709	504.46	.9	.14	759	512.15	.9	.14
610	487.94			660	496.53			710	504.62			760	512.30		
611	488.12	.1	.02	661	496.69	.1	.02	711	504.77	.1	.02	761	512.45	.1	.01
612	488.29	.2	.04	662	496.86	.2	.03	712	504.93	.2	.03	762	512.60	.2	.03
613	488.47	.3	.05	663	497.02	.3	.05	713	505.09	.3	.05	763	512.75	.3	.04
614	488.65	.4	.07	664	497.19	.4	.07	714	505.25	.4	.06	764	512.89	.4	.06
615	488.83	.5	.09	665	497.35	.5	.08	715	505.40	.5	.08	765	513.04	.5	.07
616	489.00	.6	.11	666	497.52	.6	.10	716	505.56	.6	.09	766	513.19	.6	.09
617	489.18	.7	.12	667	497.68	.7	.12	717	505.72	.7	.11	767	513.34	.7	.10
618	489.36	.8	.14	668	497.85	.8	.13	718	505.88	.8	.13	768	513.49	.8	.12
619	489.53	.9	.16	669	498.01	.9	.15	719	506.03	.9	.14	769	513.64	.9	.13
620	489.71			670	498.18			720	506.19			770	513.79		
621	489.88	.1	.02	671	498.34	.1	.02	721	506.34	.1	.02	771	513.93	.1	.01
622	490.06	.2	.03	672	498.50	.2	.03	722	506.50	.2	.03	772	514.08	.2	.03
623	490.23	.3	.05	673	498.67	.3	.05	723	506.65	.3	.05	773	514.23	.3	.04
624	490.40	.4	.07	674	498.83	.4	.07	724	506.81	.4	.06	774	514.38	.4	.06
625	490.57	.5	.09	675	499.00	.5	.08	725	506.96	.5	.08	775	514.53	.5	.07
626	490.75	.6	.10	676	499.16	.6	.10	726	507.12	.6	.09	776	514.68	.6	.09
627	490.92	.7	.12	677	499.33	.7	.12	727	507.27	.7	.11	777	514.82	.7	.10
628	491.09	.8	.14	678	499.49	.8	.13	728	507.43	.8	.12	778	514.97	.8	.12
629	491.26	.9	.16	679	499.66	.9	.15	729	507.58	.9	.14	779	515.12	.9	.13
630	491.44			680	499.82			730	507.74			780	515.27		
631	491.61	.1	.02	681	499.98	.1	.02	731	507.89	.1	.02	781	515.42	.1	.01
632	491.78	.2	.03	682	500.14	.2	.03	732	508.04	.2	.03	782	515.56	.2	.03
633	491.95	.3	.05	683	500.30	.3	.05	733	508.20	.3	.05	783	515.71	.3	.04
634	492.13	.4	.07	684	500.46	.4	.06	734	508.35	.4	.06	784	515.85	.4	.06
635	492.30	.5	.09	685	500.63	.5	.08	735	508.51	.5	.08	785	516.00	.5	.07
636	492.47	.6	.10	686	500.79	.6	.10	736	508.66	.6	.09	786	516.14	.6	.09
637	492.64	.7	.12	687	500.95	.7	.11	737	508.82	.7	.11	787	516.29	.7	.10
638	492.82	.8	.14	688	501.11	.8	.13	738	508.97	.8	.12	788	516.43	.8	.12
639	492.99	.9	.16	689	501.27	.9	.14	739	509.13	.9	.14	789	516.58	.9	.13
640	493.16			690	501.43			740	509.28			790	516.73		
641	493.33	.1	.02	691	501.59	.1	.02	741	509.43	.1	.02	791	516.87	.1	.01
642	493.50	.2	.03	692	501.75	.2	.03	742	509.58	.2	.03	792	517.02	.2	.03
643	493.67	.3	.05	693	501.91	.3	.05	743	509.73	.3	.05	793	517.16	.3	.04
644	493.83	.4	.07	694	502.07	.4	.06	744	509.88	.4	.06	794	517.31	.4	.06
645	494.00	.5	.08	695	502.24	.5	.08	745	510.04	.5	.08	795	517.45	.5	.07
646	494.17	.6	.10	696	502.40	.6	.10	746	510.19	.6	.09	796	517.60	.6	.09
647	494.34	.7	.12	697	502.56	.7	.11	747	510.34	.7	.11	797	517.74	.7	.10
648	494.51	.8	.13	698	502.72	.8	.13	748	510.49	.8	.12	798	517.89	.8	.12
649	494.68	.9	.15	699	502.88	.9	.14	749	510.64	.9	.14	799	518.03	.9	.13

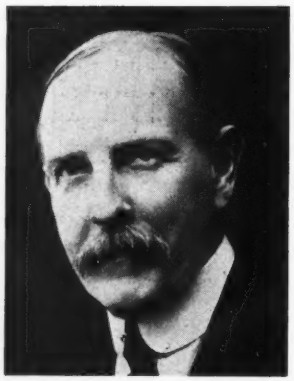
Saturated steam temperatures with proportional parts for interpolation

THE A. I. E. E. WINTER

KEEN INTEREST in all branches of the electrical art was reflected in the attendance and enthusiasm displayed at the recent Winter Convention of the American Institute of Electrical Engineers in New York, January 28-31. Interest in this notable annual event has never been lacking, but this year probably because of better general feeling in regard to business conditions throughout the nation and greater confidence, unusual enthusiasm prevailed. The total attendance of over 1200 members and guests compared very favorably with that of previous years.

A splendid technical program involving fourteen sessions, presentation of medal awards to Dr. A. E. Kennelly and Dr. Lewis B. Stillwell, an interesting lecture by Dr. Harlow Shapley, the noted Harvard astronomer, inspection trips of a wide variety of interests, and enjoyable social events were among the many features which contributed to the value and success of the meeting. The meeting opened Tuesday morning, January 28, and ended Friday, the 31st, but as has been the custom in recent years, Friday was devoted exclusively to inspection trips. Among the latter of particular interest, were the trips to the new Hayden Planetarium and to the physiological laboratories of the Columbia Presbyterian Medical Center where the application of electricity and electrical measurements to physiology were seen.

At the opening of the meeting on Tuesday morning, Dr. A. E. Kennelly of Harvard University was awarded the Mascart Medal for 1936 in recognition of his outstanding services to international electrical congresses during his long and distinguished career. This award was made by the Societe Francaise des Electriciens, and is awarded triennially to a scientist or engineer distinguished by a group of works on pure or applied electricity.



Dr. Arthur E. Kennelly, who was awarded the Mascart Medal at the convention, is one of the most distinguished members of the Institute. A life member and a past president, he has long been active in the affairs of the Institute and has represented the American electrical engineers at many notable foreign congresses. He is professor emeritus of electrical engineering at Massachusetts Institute of Technology. Last year he was elected honorary president of the U. S. National Committee of the International Electrotechnical Commission. In 1933 he was awarded the Institute's Edison Medal. He has served on the Institute's standards committee almost continuously since 1906 and on the research committee since 1920, as representative on the U. S. Committee of the International Electrotechnical Commission since 1907 and as member of the radio advisory committee of the Bureau of Standards since 1925.

In his acceptance of this honor, Dr. Kennelly graciously implied that there were many other engineers who, in his opinion, merited the honor more than he did but that it was one which he greatly appreciated. Dr. Kennelly commented only very briefly on his work on standards in his acceptance address but at the Electrophysics I session which followed immediately after the opening ceremonies, he told the story of the adoption by the International Electrotechnical Commission of the meter-kilogram-second system of units. Because of its fundamental importance, this paper perhaps was the outstanding paper presented at the convention. As pointed out by Dr. Kennelly, the K.G.S. system, or the Giorgi system, so called after Professor Giorgi of Rome who invented it in 1901, has been under consideration for many years since it involved a practical system which in many ways was simpler than the C.G.S. and practical systems now in use. At its plenary meeting of June, 1935, at Scheveningen-Bruxelles, the International Electrotechnical Commission unanimously adopted the meter-kilogram-second (MKS) system of units, 15 of the 25 constituents being represented. Dr. Kennelly in outlining this proposal made it clear that it implied no disparagement of the C.G.S. or any other existing system, nor that it was intended to immediately replace existing systems. It meant, however, that for those who see fit to use the M.K.S. system, the way is now perfectly clear.

Dr. Kennelly's paper was received with a great deal of interest and though it provoked intelligent discussion, it created no dissension, a point which Dr. Kennelly said augered well in its favor. The teaching profession was particularly interested in it and among those who discussed it from this angle were Professor Dawes, W. H. Metchner, and Dr. Jackson of Chicago. The question which arose in the minds of these men was whether the adoption of still another system of units would cause confusion in the minds of the students. As Dr. Jackson said, if the new system could be used alone, all would be well, but in view of the immense amount of existing material based upon the C.G.S. system, this is impossible. Dr. Kennelly, however, pointed out that no confusion need be necessary —that the adoption of the M.K.S. system implied no harm to the C.G.S. system—that both systems would continue to be used but that for those who wished to use it, the M.K.S. system offered great simplification.

The presentation of the Edison Medal to Dr. Lewis B. Stillwell was made at the Wednesday evening session. This is the principal annual award of the Institute and it was given to Dr. Stillwell for his distinguished and pioneer work in the field. At the presentation John B. Whitehead reviewed Dr. Stillwell's career and Charles E. Stephens outlined the history of the Edison Medal.

Astronomy and Humor—A Splendid Combination

The feature of particular interest at the Wednesday evening session was a lecture by Dr. Harlow Shapley,

MEETING *at* NEW YORK

Director of Harvard College Observatory. Though deeply interesting from a scientific point of view and thrilling in its implications, the quality of Dr. Shapley's talk was in marked contrast with the rather heavy formal exercises which had preceded it. An astronomer with the rare gift of humor and charm that Dr. Shapley possesses is unusual. For an hour or more he held the audience in almost continuous laughter and in that state he fed it amazing quantities of astronomical data which it assimilated with great dispatch. The subject of this lecture was "Progress in Measurements of the Universe" but it was delivered in an informal manner and illustrated by a startling group of photographic slides. Working away from the earth, he carried his audience further and further out into space until finally he had it some quarter of a billion light years in space. That, he implied, was the depth to which they knew the Universe at present but research is continuing and with new telescopes and new methods, this may be only a starting point for further excursions into space.

As has been the practice at the convention in recent years, all papers presented at the technical sessions had been published in full in recent numbers of Electrical Engineering and at the meetings they were presented in abstract only.

The technical program opened with two parallel sessions on Tuesday morning, one on "Communication" and the other on "Electrophysics." It was at the latter session that Dr. Kennelly delivered his paper on the adoption of the M.K.S. system of units. The only other paper at this session was one by C. F. Wagner of Westinghouse on the general subject of parallel inverters with resistance load. Inverters are comparatively new in the electrical art, and as Mr. Wagner pointed out, the calculation of inverter performance and analysis of circuit conditions has not been treated to any extent in technical literature. He presented a method of calculating in terms of two parameters the characteristics of an inverter supplying a pure resistance load and discussed the various modes of operation, including that in which the direct current supplied to the inverter flows in pulses.

This session also included a demonstration of high speed pictures of mercury arc spots by H. W. Lord of the General Electric Co. This was an exceedingly interesting demonstration. The pictures had been taken with a new Eastman high speed camera, operating at 2000 frames per second. The formation of arc spots on the surface of the mercury pool and the relation these spots bear to the value of the current was most interesting. Each spot, as Mr. Lord pointed out, was good for about 20 amp. maximum. If the current rose above that value the arc spot would divide and there would be two arc spots. The action of "arc backs" was shown with remarkable clearness. In some of the cases shown color film had been used. This clearly showed the color of the arc in the tube.

Dr. L. B. Stillwell, the recipient of the Edison Medal for 1935, was born at Scranton, Pa., March 12, 1863, and received the degrees of electrical engineer, master of science, and doctor of engineering from Lehigh University in 1885, 1907, and 1914 respectively, receiving also the degree of doctor of science from Wesleyan University in 1907. He entered the employ of the Westinghouse Electric and Manufacturing Co. and 1886 and in 1891 became chief electrical engineer, holding this position until 1897 when he was appointed electrical director of the Niagara Falls Power Co. In 1900 he established a consulting engineering practice in New York. He was a member of the National Research Council during the war and in 1920 he was elected a trustee of Princeton University for life. In 1933 he was the recipient of the Lamme medal of the Institute. He was a director of the Institute 1896-99, a vice president 1899-1901 and president 1909-10.

Communication

Four papers were presented at the "Communication" session, although only one of them was concerned directly with communication proper. This was a paper describing a cable code translator system, by A. F. Connery of the Commercial Cable Co.

The other papers at this session were concerned with materials, equipment and methods of measurement in communication work. A. H. Lamb of Weston Electrical Instrument described applications of a dry disk photoelectric cell. E. E. Spitzer of R. C. A. Mfg. Co. delivered a paper on anode materials for high vacuum tubes, and a paper by Barstow and Bly of the Bell Telephone Laboratories and H. E. Kent of the Edison Electric Institute discussed the measurement of telephone noise and power wave shape. The question of noise in telephone circuits is one that is of mutual interest to both power and telephone engineers since it is in the power lines that much of the interfering noises originate. Of fundamental importance in this problem are the relative interfering effects of various frequencies. This factor was discussed in a paper before the A.I.E.E. in 1919 by H. S. Osborne in which the telephone interference factor meter for measuring power system wave shape in terms of its influence on telephone circuit noise was first proposed. Since the original introduction of devices for measuring or rating the wave shape of power system currents in terms of their influence on exposed telephone circuits, much additional work on the problem has been done and this was the subject of this paper. In Part I of the paper a curve of relative interfering effects based upon recent studies was presented and the characteristics of a meter for measuring telephone circuit

noise described. In Part II of the paper, a new telephone influence factor weighting curve was presented and a comparison given between results obtained by meters embodying weighting networks based upon the old and new curves. As pointed out by the authors, two methods of measuring telephone circuit noise are in use in the Bell system at present. One of these methods is subjective, i. e., uses human hearing mechanism as a part of the measuring apparatus, and the other is objective or yields noise measurements without the aid of human hearing. Various kinds of noise were measured, but because of the increasing use of rectifiers on power circuits special measurements were made on noises arising from rectifiers. An analysis of average rectifier noise is shown in Fig. 1.

Among the various subjects which received consideration at the afternoon sessions on Tuesday, one of

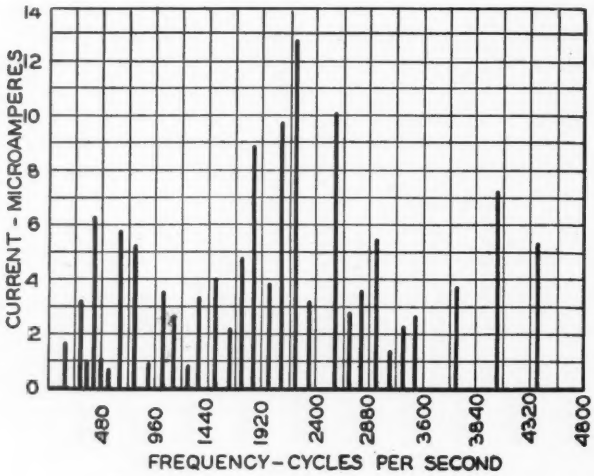


Fig. 1. Analysis of average rectifier noise

particular interest to designers of high power electrical systems was the one on Bridge Measurement of Electromagnetic Forces by A. C. Seletzky and G. L. Priday, both of the Case School of Applied Science. While considerable work has been done in the mathematical treatment of electromagnetic forces between members of an electric circuit, the actual measurement of these forces has received comparatively little attention, and as the authors pointed out, as far as they could ascertain, with the exception of torque measurements in electrical instruments, all such measurements have been direct physical measurements of the forces involved. Such measurements necessarily involved heavy currents and special means of measuring the actual resulting forces. The purpose of this paper, therefore, was to show that it is entirely feasible to measure such electromagnetic forces by means of an impedance bridge. This bridge measures the variation of inductance of a disconnecting switch as the switch blade is displaced by slight amounts from the closed position. The electromagnetic forces tending to open the switch blade, calculated from the observed variation, checks the theoretical value obtained from Dwight's formula. The bridge may be used to determine the forces acting on current carrying members the configuration of which is such as to make accurate theoretical calculation impossible. The circuit diagram of this bridge, with the disconnect at the upper left, is shown in Fig. 2.

High Speed Pictures by Dr. Edgerton

Since Dr. H. E. Edgerton began work with high speed motion and still pictures several years ago, his fame in this field has become national and his pictures have been of interest to the layman as well as the engineer and scientist. His paper on High Speed Motion Pictures at the Instruments and Measurements session, therefore, was of great interest. After briefly outlining the principles of his system of photography, Dr. Edgerton presented a series of remarkable pictures taken with it. These pictures included such varied subjects as a house fly taking off from a plate of jam, a snake's tongue in action, a drop of milk falling into a cup of ink, a carrier pigeon taking off, the movement of springs, a soap bubble bursting, etc. While these non-technical pictures are of general interest, Dr. Edgerton pointed out that the method was of great value in the study of mechanical equipment of all kinds. It bears the same relation to mechanical movement that the oscillograph does to electric currents.

Looking for Something Simple

Another paper of rather unusual interest at this session was that by L. A. Dogget and H. I. Tarpley on Positive and Negative Power and Energy. In this presentation, the authors, both of Penn State College, described an intensive study made in an attempt to clarify the definition of power, power factor and related quantities. As the authors pointed out, the concept of "power factor" has not kept pace with the development of the art. In the good old days of direct current, power was the product of current and voltage. This constituted a law as fundamental as Ohm's law. To deny it was an act of heresy, and a president of the British Institution of Electrical Engineers prior to 1884 wrathfully said to an engineer who had experimental proof that in alternating current practice the power was not always equal to the product of the voltmeter and ammeter readings, "You're a liar." Investigation soon proved the past-president wrong and the concept of power factor was born. But in all these 50 years it has remained a difficult problem. The concept, though exceedingly simple and useful in sinusoidal cases, has become increasingly involved as engineers have tried to modify it to cover nonsinusoidal cases and unbalanced polyphase systems. Even to this day engineers have not gotten over the easily demonstrable fallacy of multiplying voltmeter readings by ammeter readings in nonsinusoidal cases. This product is absolutely meaningless. In an attempt to clarify this situation the authors sought a new line of approach and since May, 1934, have been involved in an intensive study of positive and negative power, and of positive and negative energy. Positive and negative power are entities. Whenever the voltage and the current are positive, the power is positive. If either of them is negative and the other positive, the power will be negative. If both are negative, the power is negative. The statement of this definition, and the method of measurement of these quantities are perfectly general and not limited to sinusoidal conditions.

The equipment for measuring this positive and negative power as shown by the authors was very simple, consisting of wattmeters, copper oxide rectifiers, a thermionic rectifier and suitable transformers. See Fig. 3. The tests made by the authors were extremely interesting and proved that positive and negative energy could be measured with apparatus commercially available. The method was recommended only for nonsinusoidal cases, however.

Naturally this paper was received with a great deal of interest and it provoked interesting comment. There seemed to be general agreement that something was needed other than "power factor" to explain nonsinusoidal cases. However, as A. E. Knowlton pointed out, though this use of "power ratio" clarifies the matter for the layman and practical man, it introduces complications for the technically or rather the academically inclined. Neither would it be of particular use to the designer. Professor Howe of the U. S. Naval Academy discussed the paper and presented a case of a circuit supplying a rectifier. In this case the negative loops of the wave are cut off and Mr. Howe wanted to know what became of the negative power in this case.

A wide variety of interests characterized the papers presented at the three parallel sessions held Wednesday morning. At the Power Transmission session there were papers on, 1. The loading of underground cables; 2. The behavior of cellulose insulation; 3. The resolution of surges on transmission lines; 4. Corona losses at 230 kw. and lightning currents in field and laboratory. At the Synchronous Machinery session, there were papers on, 1. Angle switching; 2. Load losses in synchronous machines; 3. Pull in Characteristics of Synchronous motors; 4. Characteristics of Sliding contacts, and 5. Losses in single phase induction motors. And finally, at the session on Electrochemistry, there were papers on, 1. Development of electrochemistry; 2. Induction heating at low temperatures; 3. Electric furnaces with carbon radiators, and 4. Power companies' service to arc furnaces.

When the Lights Went Out in New York

The most interesting event on the Wednesday morning program, however, was a discussion which had not been formally incorporated in the convention program. This was a short account by H. C. Forbes, System Operator of the New York Edison Co., of the accident at Hell Gate Station which occurred on January 15. This accident, occurring at 4:16 P. M., created considerable disturbance in the upper part of Manhattan and though its extent so far as the entire system was concerned was comparatively small, it gave evidence of what might happen in a metropolitan area such as this in case of a really major disturbance. As Mr. Forbes pointed out, the facts are not entirely clear but it is quite evident that the trouble started when a ground occurred on phase C of section 4 of the main bus at Hell Gate. At the time there were two generators on this bus, a 40,000 kw. unit and a 160,000 kw. unit. Shortly afterwards, a ground also appeared in section 5-6 of the auxiliary bus, on the A phase, to which generator 8, also a 160,000 kw. machine, was connected. These 160,000 kw. machines are both cross compound units and the neutrals of the high pressure elements are grounded. When the fault occurred, these machines immediately began to feed current into the ground through the neutral connections. This current attained a high value, so high that it actually burned off the neutral connections. Just why the fault on section 5-6 of the auxiliary bus occurred is not clear. This bus, of course, was effectively isolated from the main bus by solid barriers and it seems unlikely that the hot gases developed from the initial short circuit could have reached and caused the breakdown of the auxiliary bus. As Mr. Forbes explained, when the neutral on generator 9 burned off, it is possible that a surge was set up sufficiently severe to cause the breakdown of the auxiliary bus. Another thing occurred; when the neutral burned off on generator No. 9, the

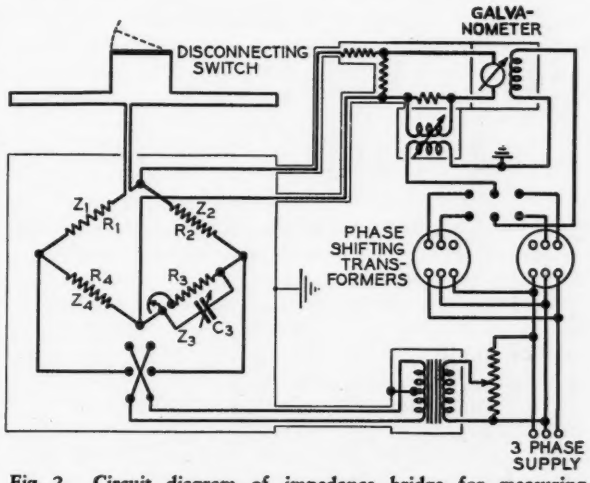


Fig. 2. Circuit diagram of impedance bridge for measuring electromagnetic forces

oil in the oil circuit breaker in this lead caught fire and the conflagration was communicated to the neutrals of two other machines and so they were put out of use.

Although there were only two generators on the bus when the accident occurred, the main bus and also the auxiliary bus was tied in with a number of other stations. There was, for example, the 132,000 v. tie to Dunwoodie which forms a tie with the Niagara Hudson system, a tie with Waterside and Hudson Ave., another with Sherman Creek. The approximate set up was as shown in the accompanying diagram (Fig. 6) which is reproduced from Mr. Forbes' sketch on the blackboard.

Bus sections 4 and 5-6 of course were completely out and could not be restored to service. Sections 7 and 8 were in suitable condition and were restored several hours after the accident.

There were many other repercussions of this disturbance which need not be described here, but on the whole they were of a minor nature compared to the primary disturbance. As far as New York City was concerned, the trouble was fairly well confined to the district between 59th St. and 129 St. In terms of customers, only some 40,000 out of a total of around 2,000,000 were affected.

As soon as possible after the accident, the damaged sections were isolated and current from ties to other

stations delivered to the undamaged feeders and distribution system. This was done as shown in Fig. 6B, which shows how the tie lines and feeders connected into the main and auxiliary buses. By operating the two upper breakers, current was fed from the tie across the connecting bus to the distribution feeders.

There is not space in this report to discuss all of the papers at the Wednesday morning session in detail and since a number of them are of specialized interest to only a few in the field, we will consider only those which are of more direct interest to those in the power field.

The paper by C. C. Shutt and J. W. Dawson, both of Westinghouse, on Angle Switching, for example,

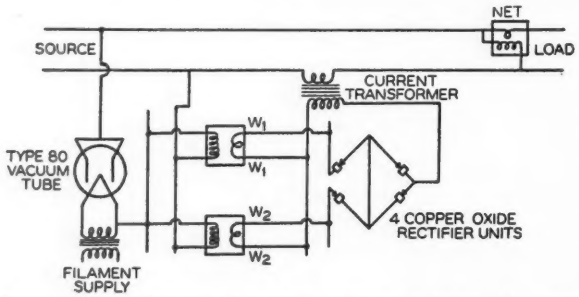


Fig. 3. Wiring diagram of apparatus for measuring positive and negative power and energy with the necessary meters

was of particular interest. Angle switching refers to a method of starting synchronous motors whereby the time of application of the excitation voltage with respect to the relative angular position of the field poles and the impressed voltage is controlled. One of the chief advantages of such control is to increase the torque against which the motor will consistently pull into step with a given value of starting current. In their paper, the authors described commercial applications of this method of starting. The equipment used consists essentially of a means of checking the position of the rotor against the space position of a particular phase winding at a predetermined point on the wave of voltage impressed across that phase. This angle switching equipment is used in conjunction with synchronous motor starting control of standard type. The control functions in an ordinary manner up to the point of applying the excitation voltage, but instead of applying the excitation at this point, the angle switching equipment is energized. This device, in turn, applies the excitation voltage to the motor the first time the rotor and the impressed voltage pass through the predetermined relative angular relation.

Another interesting paper at the Synchronous Machine session was one on Sliding Contacts by R. M. Baker of Westinghouse. Experiments with oxidized and oxide free materials indicate that the electrical characteristics of the ordinary sliding contact such as that between a carbon or graphite brush and a copper slip ring are dependent upon the oxide film on the surface of the ring. The results of these experiments were presented in the paper together with an explanation of the breakdown of the oxide film by the increase of current through the contact. The film, according to the author, is broken down by the passage of current, and the contact resistance, therefore, decreases with increasing current. Liquid films can affect the contact drop directly only when these films are of oil or some other liquid having a low vapor pressure. Water films probably produce a very desirable lubricating effect in a sliding contact, but do not tend to raise the brush off the ring and, thereby, increase the contact drop. The water films which lubricate the contact are thin in comparison with the unevenness in the contact and are extremely tough. The current flows through these very thin films with no appreciable loss in voltage. The author also found that appreciable thermal voltages can be measured in a sliding contact if the ring carries an oxide film. These voltages disappear immediately when the oxide film is removed by sanding the ring surface.

This paper also created considerable favorable comment, and Mr. Baker's findings were substantiated by others who had done work in the field. The oxide film apparently is a very important factor in the operation of any sliding contact and a knowledge of its characteristics and methods of controlling it should help to bring about improved performance in our rotating machinery.

Those concerned with electrochemistry and electrometallurgy found the session devoted to this branch of electrical engineering of particular interest. One of the features of this session was the description of a new type of electric furnace by Henri George of the Saint Gabain Co. in France. This furnace which was developed for operation at very high temperatures has a heat producing element in the form of a carbon electrode raised to a high temperature and conveying heat to the charge by radiation. In one form of this

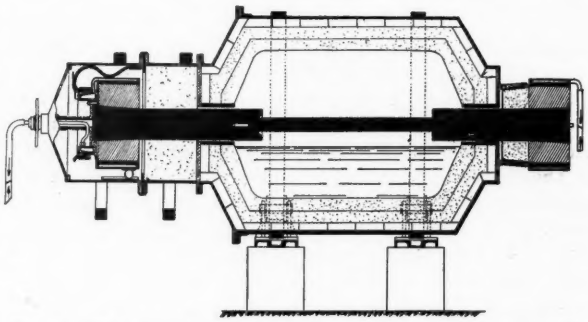


Fig. 4. High capacity single phase carbon radiator furnace without magnetic losses. The steel frame comprises a copper lining which serves as a return for the current

furnace, the steel frame comprises a copper lining which serves as a return for the current, an arrangement which eliminates magnetic losses. This form is used in sizes where the current is above 5000 amp. The author unfortunately was unable to be present, so his paper was presented by another member.

The engineering development of electrochemistry and electrometallurgy were discussed by another French representative of the profession, Paul Bunet of Paris, who also was unable to present the paper in person. This paper presented the status of development in this field in France and discussed the general problem of supplying electric power to the electrochemical and metallurgical industries. This paper, by a distinguished French engineer, contained considerable information not readily available to American engineers.

The symposium on Magnetic Materials was notable in that it gave splendid evidence of the progress that

has been and is being made in the development of better magnetic material. In this field, as pointed out by R. M. Bozorth of the Bell Telephone Laboratories, progress in the theory still lags far behind experimental progress. Advances in the theory of ferromagnetism, however, has been particularly rapid during the past 5 or 10 yr. Although Ampere suggested over 100 yr. ago that molecules might behave as magnets because of the electric currents circulating in them, it was the spectroscopist who quite recently supplied the elementary magnetic particle. It is the spinning electron. In order to explain spectroscopic observations it has been necessary to revise the picture

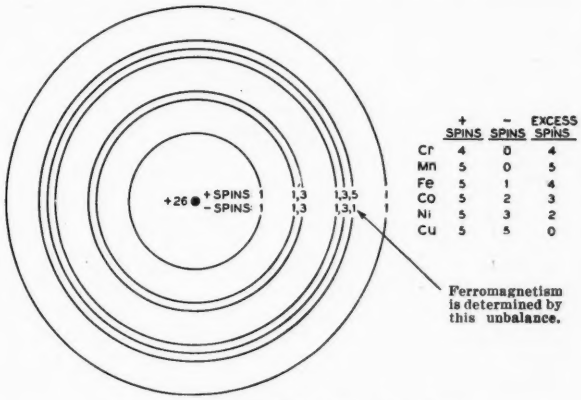


Fig. 5. Electron shells in the iron atom

of the atom. For some time it has been supposed that an atom is made by a heavy nucleus with a positive charge and of electrons moving in orbits around the nucleus. To this picture now must be added the idea that each electron itself is spinning about on axis that passes through its center. Each electron in an atom is then a small gyroscope, possessing a definite magnetic moment on account of its charge and a definite angular momentum on account of its moving mass. Electrons revolving in orbits also exhibit both magnetic moments and angular momenta due to their orbital motions, but for these the ratio is just half what it is for the spinning electron.

It is on the basis of these spinning electrons and the magnetic effects of the orbital motions of the electrons that ferromagnetism is explained. The picture of the iron atom as now envisioned by experts is represented in Fig. 5. The 26 electrons in iron atoms are divided into 4 principal shells as shown. The first (inner) shell contains 2 electrons, the next 8, the next 14 and the last 2. As the periodic system is built up from the lightest element, hydrogen, the formation of the inner shells begins first. When completed, the number in the first 4 shells are 2, 8, 18 and 32, counting outward, but the maximum number in each shell is not always reached before the next shell begins to be formed. For example, when formation of the fourth shell begins, the third shell contains only 8 electrons instead of 18; it is the subsequent building up of this third shell that is believed to be connected intimately with ferromagnetism. The inserted numbers show how many electrons having positive and negative spins are present in each shell and it may be noticed that in all but one there are as many electrons spinning in one direction as in the other. This means that such shells are magnetically neutral and cannot have magnetic polarization. In the third shell, however, which is not yet filled to this extent, there are 5 electrons with positive spins and 1 with a negative spin, leaving an unbalance of 4 units of spin in one direction. If one more positive charge and its associated mass be added to the nucleus and one more electron in an outer shell, the iron is transformed into cobalt, and by repeating the process, the cobalt is transformed into nickel. These additional electrons in iron and their spins are so oriented that there is what might be called an excess spin of 4 units in iron, 3 in cobalt, and 2 in nickel.

This is not the entire story, but it gives a clue as to where the explanation for ferromagnetism lies. Mr. Bozorth, in his papers, discussed the entire theory of which what we present here is only the beginning.

G. W. Elmen, also of Bell Telephone Laboratories, discussed the properties of modern magnetic alloys of iron, nickel and cobalt and described the part they are playing in the advancement of electrical communication. The use of silicon steel in the communication field was the subject of a paper by Crawford and Thomas, both of General Electric, and C. S. Williams of Westinghouse presented a paper on the general subject of permanent magnet materials.

In the discussion of these papers, one of the engineers of the Southwestern Bell Telephone Co. of St. Louis directed attention to the effect of strain in magnetic materials—that strain in some way creates electromotive forces. For example, he pointed out that if an amplifier is connected across a tightly stretched steel or iron wire and this wire is "plucked," the amplifier and associated telephone will reproduce the note of the vibration—one octave higher. Other speakers also cited examples of the strain which obviously exists in magnetic materials. In a number of cases this strain finally asserts itself in the form of cracks in the materials.

A development of unusual interest at the Electrical Machinery session was described in the paper by Schmidt and Griffith of General Electric, "A Static Thermionic Tube Frequency Changer." This development was described on page 677 of the December 1935 issue of Power Plant Engineering and involved replacement of an engine driven generator by a bank of vacuum tubes.

Another unusual development was that described by G. T. Southgate in his paper, "Vibratorily Commutated Stationary Conversion." This described a system of stationary conversion of electric energy from a.c. to d.c. in which the commutation is effected by harmonically vibrating contacts actuated electromagnetically.

This development created unusual interest because of its novelty and simplicity. For as those that discussed it pointed out, this device offered high efficiency of conversion, low first cost and freedom from complications such as are inherent in other types of rectifiers. If it can be built in sizes up to, say, 100 kw. it probably could be used in many applications where mercury arc rectifiers are required today.

The Symposium on modernization of distribution lines brought out a number of interesting facts regarding the value of recently developed equipment on existing lines. The addition of expulsion or Deion

gaps, counterpoise wires, ground wires were all shown to be of distinct value. New types of lightning arrestors, the use of wood for impulse insulation, grading rings and arc shields and Peterson coils also were shown to be effective where applied properly. These elements of modernization of transmission lines were presented in a paper by the Lightning and Insulator Subcommittee.

Modernization of power distribution systems was the subject of a paper by H. P. Seelye of the Detroit Edison Co. Among other things, Mr. Seelye described the development of a new underground farm line. This cable is designed for single phase lines with one side grounded. It is laid directly in the ground by a special plow. The author pointed out that there has been a tendency in the past to use poles which were stronger than necessary for the loads carried and as a consequence an "American Standard" classification has been set up which allots a definite strength rating to 7 specific classes. The use of bare wire for long span farm "primaries" was discussed. It was pointed out that the weatherproof covering on wires constitutes very nearly 30 per cent of the total weight. Transformers, regulators, outdoor metering and appearance of overhead lines were other topics of Mr. Seelye's paper.

In the discussion of this paper, A. W. Jones of the Philadelphia Electric Co. cited the success of their experience with Deion gaps, reporting that on several installations where Deion gaps were installed no trouble due to flashovers had been experienced. They had had some trouble in the corrosion of these gaps, however. Wood pole insulation in their experience did not seem very effective. Mr. Waldorf of the Pennsylvania Water and Power Co. in commenting on protective measures said that for all practical purposes immunity from lightning disturbances can be obtained by the use of two overhead ground wires and by properly co-ordinating the tower footing resistance with insulation strength.

Mr. Bellaschi of the Westinghouse Electric & Mfg. Co. described a recently developed combination high voltage and current generator. With this test unit, breakdown of the insulator was initiated by a 2,000,000 v. impulse surge which was immediately followed by a high current surge. This, he pointed out, more nearly approached the actual conditions of lightning than methods heretofore available.

Philip Sporn of the American Gas & Electric Co. corroborated Mr. Seelye's conclusions regarding the advantage of small substations. He reported the use of bare conductor for both primary and secondary farm lines on their system. So far, however, they have been unable to solve the underground farm line.

C. A. Muller and H. E. Turner, both of the American Gas and Electric Co., presented the picture in regard to "relays" in this modernization symposium. As they pointed out, relay systems vastly superior to those in use 5 yr. ago are now available. The principal change has been the development of the high speed relay, the operating time of which may be as low as one cycle or less on a 60 cycle system. High speed relays, especially when used with high speed circuit breakers, result in reduction of damage at stations and on lines and give improved system stability and operation. Reduction of outages on equipment of industrial concerns also has been an important advantage.

E. H. Banker of the General Electric Co., in discussing this paper, stressed the advantages of "carrier" over pilot relaying. No system is stronger than its weakest link, he said, and in a wire system, this weakest link is the wire itself. With "carrier," however, the wire approaches perfection itself. One cycle carrier systems, he said, are now commercially available at reasonable prices.

At the Transportation Session, the paper of outstanding interest was the one by N. W. Storer of Westinghouse, describing the Bi-way system of Electric Platforms for mass transit. This novel system provides a carrying capacity of 60,000 persons per hour compared to an average of 20,000 to 30,000 with our best systems of subway transportation.

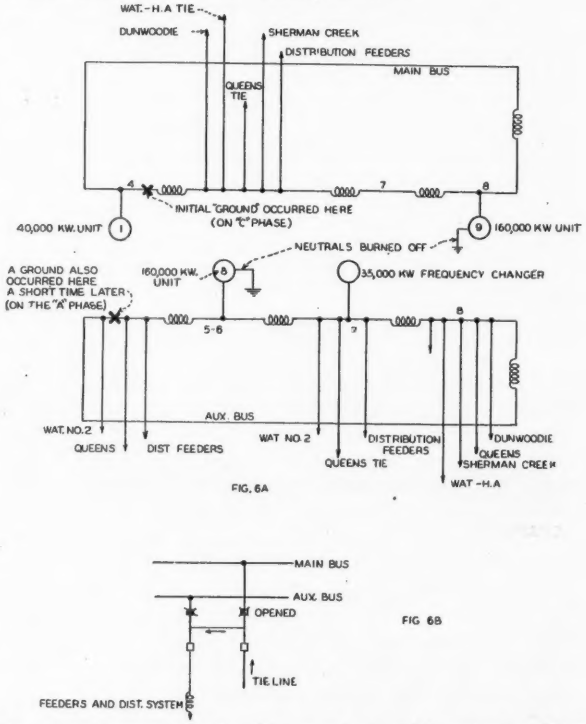


Fig. 6. Diagram showing the conditions which existed at Hell Gate Station at the time of the accident on January 15

The closing session on Electric Welding proved to be one of the most interesting of the meeting because of the fine demonstration of ignition control equipment for welding. This demonstration was given by engineers of the Westinghouse Co. and it proved the very fine accuracy of this method of control.

At this same session, the chief electrical engineer of A. O. Smith Corporation presented an unusually interesting demonstration of the application of high speed photography to the study of the flash welding arc. H. A. Winne of General Electric also showed the application of high speed photography to the study of welding phenomena. These pictures were taken at from 800 to 1200 frames per second. The remarkable thing about the flash welding pictures was the fact that instead of a continuous arc, as the arc in a flash weld appears to the eye, the high speed camera showed it to be a series of short circuits occurring independently along the line of the weld.

Case Studies in Power Economics

Conducted by
ZUCE KOGAN,
Kogan Industrial Service
Chicago, Ill.

$1000 Saved by Study of Available Electric Rates

AN INTIMATE knowledge of rates being offered by the local utilities many a time will benefit the purchaser of power or any other commodity from utilities. Most of the large utilities have scores of rates to meet some particular occasion as may have arisen in the course of the life of the utility. It is by fitting these rates to the condition that one may bring about a reduction in his cost of power, fuel, steam, or whatever the commodity may be.

This intimate knowledge of rates would tell, for instance, the interested party of the possibility of taking advantage of a rate which calls for curtailment of power for certain periods of the day during certain seasons. Another would be how to make use of a combination of several rates and how to take advantage of the combination.

Taking advantage of the first is quite well-known, as during the last few depression years many a large consumer of power has gone on the so-called limited-hour rate, which calls for the curtailment of power during the evening hours in the winter months. As far as taking advantage of several rates, this is not quite as prevalent. We shall therefore relate here how a consumer of power brought about a reduction in his power cost by changing his rates every year.

This consumer of power was a manufacturer of automobile and refrigeration accessories. His season began in the month of May and production kept on increasing till it reached a peak in October.

This peak kept on for two months, whereupon it gradually receded, until it reached a low point in the month of February, and it stayed at that point through April. In May the cycle began again.

The tabulation herewith indicates the various monthly demands from the beginning of the season to the end, representing an average condition for each month for a period over 10 yr. (They were not hit very much by the depression.)

Month	Demand	Month	Demand
May	600 kw.	Nov.	1010 kw.
June	680 kw.	Dec.	950 kw.
July	880 kw.	Jan.	900 kw.
Aug.	920 kw.	Feb.	550 kw.
Sept.	980 kw.	Mar.	550 kw.
Oct.	1010 kw.	April	550 kw.

They were purchasing power on a monthly demand basis. That is, they paid for the demand each month as it was established. Their monthly rate was as follows:

$2.00 per kw. demand for the first 200 kw.
$1.70 per kw. demand for the next 300 kw.
$1.50 per kw. demand for anything over 500 kw.

Their average demand charge by month was as follows:

Month	Charge	Month	Charge
May	$1060.00	Nov.	$1705.00
June	1180.00	Dec.	1585.00
July	1480.00	Jan.	1510.00
Aug.	1540.00	Feb.	985.00
Sept.	1630.00	Mar.	985.00
Oct.	1705.00	Apr.	985.00
		Total	$16350.00

After we had studied this condition, and being amazed at the regularity of the ascending and descending demands, we found that the yearly demand rate offered by the same utility would be highly suitable to this client, provided he did not have to go on that rate every year. The rate was as follows:

The first 200 kw. demand at $2.00 per kw.
The next 300 kw. demand at $1.50 per kw.
The next 500 kw. demand at $1.30 per kw.
Anything over 1000 kw. at $1.15 per kw.

The provisions of this rate are that the customer must pay the highest demand established for the next 12 months unless a higher demand has been established during that period, whereupon this high demand has to be paid for another period of 12 months, and so, ad infinitum. This fact that the customer had to pay a high demand once it is established, for even a period during which he has a very low demand, did not make it impossible to use it continuously. There was another provision in the rate, however, which permitted the customer of the utility to change the rate to the normal monthly rate after the customer has been operating for 12 months under this yearly rate. Recalculating the monthly demands on the basis of a yearly rate for the first season if he were to apply for this rate before February, would have been as follows:

Month	Demand	Charge	Month	Demand	Charge
Feb.	550	$915.00	Aug.	920	$1427.20
Mar.	550	915.00	Sept.	980	1505.20
April	550	915.00	Oct.	1010	1542.70
May	600	980.00	Nov.	1010	1542.70
June	680	1115.20	Dec.	950	1542.70*
July	880	1375.20	Jan.	900	1542.70*
			Total		$15317.60

*The demand charge for this month was the same as that of the month of November, which happened to be the highest.

From the above tabulation it is quite evident that as long as the demand from month to month keeps ascending, the demand charge per month would be, on

the yearly rate, much less than on the monthly rate, for the simple reason that when the demand is ascending, the customer pays only for the demand as it is established, and the yearly rate is lower than the monthly rate. If the demands begin to descend, however, the customer is obliged to pay not for the demand as it is being established, but for the already high demand established in the previous months.

Therefore, from the above tabulation, it is quite clear that if the purchase of power were to be continued on the same yearly rate, the demand charge would have been the same as the high demand already established. In other words, the yearly demand charge would have been a sum equivalent to 12 × $1542.70 or $18,512.40, a sum which is much larger than their yearly demand charge on the monthly rate. It is obvious, therefore, that after 12 months' purchase on the yearly rate, as is necessary by contract, that the customer should immediately return to the monthly rate.

We turned these figures over to the local utility for corroboration. These figures were corroborated and now the manufacturer is enjoying a saving every other year of over $1,000 by operating alternately on the yearly and monthly demand rates.

Economical Production *of* Air *in the* Forge Shop

Air Can Often Replace Steam in the Forge Shop to Advantage but the Advantages of a Carefully Planned Piping System Must Not Be Overlooked

By PAUL M. THAYER

MANY MANUFACTURING PLANTS have forge shops for the purpose of making forgings which necessitate the intermittent use of forging hammers. Where these hammers are of large size the cost of steam for operating them runs into surprisingly large figures per unit of production. Some plants have attempted to solve this problem by using air from their general shop system instead of steam.

While this arrangement will undoubtedly reduce the cost of power to operate the hammers, there are many factors entering into the problem such as the disturbances in the distribution and pressure of air in the general shop system, that may more than offset the gain in lowered operating cost resulting from such an arrangement. The advantages in operating hammers by air demonstrated in some of these jobbing installations, has led to the use of air in certain production forging plants which were equipped with compressing plants and distribution systems entirely independent of the general air system of the rest of the plant.

The writer had the opportunity to aid in laying out two of the largest and most important installations of this type which have been built in recent years. Some of the ideas which were worked out and later tested in actual service, may be of interest to the readers.

Type of Plant Important

There is little similarity between the operating conditions existing in a plant that turns out automobile forgings on a production basis and one turning out the many different forgings for a battleship or locomotive. In the first instance the pieces to be forged are all of one kind on a hammer and they are forged in dies with a specific number of blows required to produce the piece; crews operating hammers in this class of work become so proficient that there is no noticeable interval between the completion of one piece and the starting of the work on the next piece. During production, there are very few idle blows or periods during which the drop hammer is floating.

In shops whose production consists of a relatively small number of heavy pieces, the conditions of operation are totally different. In this event the hammers are idling more than they are working, in the case of steam operated hammers, or are shut down entirely in the case of air operated hammers. Since there are so many factors involved, and every plant has its own particular problems, it is impossible to make any general statements that would be applicable to every installation.

Builders of hammers have always made steam hammers and they have been reluctant to push the use of air as a substitute for steam. The builders of air compressors have been interested in fields that promised a larger volume of business for their machines than the forging shops of the country and have neglected this field. As a consequence of these facts, there is little real information available to anyone who is interested in making a study of a particular problem involving the application of air to a forge shop.

Advantages of Air

Before going into the many points to be considered in an installation of this kind it might be well to point out some of the advantages of using compressed air to operate forging hammers. In the first place a forge shop is usually an uncomfortable place for the men to work in both in summer and winter; the furnaces are usually placed as near the hammer as possible to facilitate the transfer of the hot pieces to the hammer; the dies, anvil, and hammer become hot; and, where steam

is used, the entire frame gets hot too; steam usually leaks from the stuffing box around the piston rod and blows around the operator's head; the dirt around his feet catches the hot scale from the material being forged.

Use of air corrects a few of these difficulties. As air expands in the cylinder of the hammer it cools, any leakage blowing down over the operator tends to refresh him; the cylinder and frame of the hammer keep cool at all times; the discharge from the hammer can be utilized to ventilate around the hammer and furnace if desired, or it can be connected into a low pressure receiver and used as part of the air supply for the furnaces.

Another very important advantage of the use of air over steam is the fact that it is necessary to warm up a steam hammer for a quite considerable time before a full force blow can be struck; it is also necessary to keep the hammer idling between heats in order to prevent loss of time due to the cooling down of the cylinder, if this is not done in those shops where the actual forging work is intermittent. This necessity to get the hammer hot and to keep it hot between heats causes an excessive use of steam.

An air hammer can strike a full force blow regardless of whether it has been operated the minute previous or not for a month. Since the warming up time each day is part of the working period of the crew it means that there is a considerable loss of time on the part of the crew which is directly chargeable to the use of steam, the saving of this time and production is properly a credit to the use of air. In many plants the actual time lost due to warming up the hammers amounts to as much as half an hour a day; in view of the present tendency to shorten the working day to 6 hrs., it can be seen that this becomes an important item of saving in favor of air operation.

Full Pressure Necessary

It is of vital importance that each hammer in a plant get its air at the pressure at which it is designed to operate, usually 90 lb. per sq. in. In order to do this it is essential that the supply of air be ample to take care of the fluctuations in demand imposed on the system by the various hammers in the plant. There are two ways in which this ample supply of air can be assured, one is by installing compressor capacity sufficient to handle the peak demand of all the hammers operating at once. The other is to provide receiver capacity to supply this peak demand with compressor capacity sufficient to handle the average load most economically.

The first solution is the easiest one to figure out, but the probabilities are that the cost of power to compress the air would be excessive. The second solution seems the more intelligent one in most cases. It is surprising how little real information there is on this subject of the proper relationship between compressor capacity and size of hammers.

Some of the hammer builders have a rule of thumb method of determining the proper size of compressor to use, but an actual check of the various plants in the country reveals the fact that the relationship of compressor capacity to total falling weight differs from the recommended sizes more than one hundred per cent each way. This wide divergence of relative capacities may have been required by the differences of operating conditions in the different plants; but more probably it was occasioned by the desire of the management to either "Play safe", or "Take a chance."

Layout of the plant and the arrangement of the air receivers and the hammers can easily have more influence on whether the various hammers get a sufficient supply of air at the correct pressure than even the capacity of the compressors supplying that air. This fact has been given all too little attention in most of the forge shops that have come under the writer's observation.

In one plant, which was one of the most important air operated forge shops in the country, the hammer shop was laid out at right angles to the compressor plant. The three compressors discharged into a common header, which, in turn was connected to a battery of air receivers. The line from the receivers went down the center of the forge shop, each hammer being supplied from the single main air header. There were several large hammers located next to the compressor end of the header, with the smaller hammers located at the outer end of the air main.

When the large hammers were in operation, the pressure at the outer end of the main dropped greatly, at times it was only possible to get 65 lb. per sq. in. at the last hammer although the governors on the air compressors were set at 115 lb. When the large hammers were not operating, the pressure at the end of the air main would rise almost to the receiver pressure. It was impossible to get uniform operation and uniform product from the hammers that were handicapped with this widely varying air pressure. The layout of the air mains and air receivers described above is an example of the copying of a typical steam forge shop layout, but using air instead.

Such an arrangement is desirable for a steam operated plant because it cuts down the amount of steam piping to keep hot and consequently it cuts down the loss due to condensation. The receivers were located the same as the boilers of a steam plant would have been. The pressure drop in a steam line operating under the conditions described above would not have shown anywhere near as great a difference as it actually was with air. This question of pressure drop and consequent unsatisfactory operation of the small hammers at the end of the line made many engineers question the desirability of using air in forge plants where large size hammers were installed.

Inasmuch as this particular company had plans for the construction of a new forge shop with even larger hammers installed, the question of how to avoid this excessive pressure drop in the air mains, still keeping the unquestioned economies of air operation, was a vital one. The writer made a study of this problem, and worked out a scheme that was adopted with most gratifying results.

Loop Header Used

The basic idea was to so locate the compressors, receivers, and main air headers, that the action of the large hammers would be felt most quickly on the governors of the compressors without drawing down the

air pressure on the system as a whole. In this manner the compressors could make up the deficiency in quantity of air supply before there was a serious drop in the air pressure of the system as a whole. In order to accomplish this purpose, the largest hammers were located near the compressor plant with only a relatively small receiver between the compressor plant and the loop air line serving the hammers in the forge shop.

Use of a loop air header in place of the conventional single line down the center of the plant was decided upon in order to give the air a chance to feed either way from the compressor plant to the main air receivers which were located at the opposite side of the plant from the compressors. It will be seen that, with the hammers all located between the compressors and the receivers, there are in reality two sources of supply for any sudden demand for air, the first and most important being the compressor plant itself, the second and auxiliary source being the receivers.

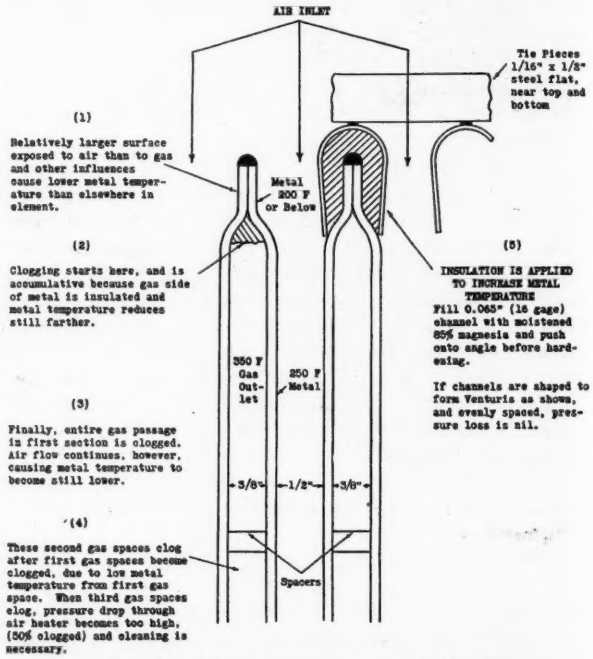
When a very large hammer is suddenly put in operation there will be a sudden and heavy demand for air, since these hammers are all located near the compressor plant, this heavy demand will be felt there first with a corresponding reduction in pressure at that point, there being very little receiver capacity at the compressors, this reduction in air pressure will react on the governors almost immediately, and the output of the compressors will be increased before there has been a sufficient drain on the large receiver capacity located at the opposite side of the plant from the big hammers. At the same time the balance of the plant has been taken care of by the storage of air in the receivers.

After the plant was placed in operation for a sufficiently long period of time to cover all the many possible combinations of hammer sizes in operation, it was found desirable to reduce the pressure at which the governors of the compressors was set from 115 to 95 lb., as the drop in pressure in the plant, even with the largest hammer in operation, hardly ever exceeded 3 lb. There is a considerable saving in power possible in operating a compressor at 95 as compared to 115 lb. This saving in power was directly attributable to the layout of receivers, air headers, and compressors for that particular installation.

As mentioned previously in this article, no two forge shops operate under exactly the same conditions, hence it is hardly likely that a layout which handles one set of conditions admirably would work out best under totally different circumstances. The best way to determine the proper arrangement and size of air compressor required for any given plant is to make a thorough analysis of just what goes on in the plant, then determine the results that should be achieved, from these two viewpoints work out a solution that, for that particular plant, will take the conditions that have been determined to exist and produce the results that have been set as the goal. There is a fertile field for improvement in forge shop operations, and the substitution of air for steam in many of them would return a large profit on the investment required.

Air Heater Clogging

CORRECTION of clogging difficulties in four 77,500 sq. ft. plate type air heaters by means of insulation was described by the Milwaukee Electric Railway & Light Co. in Bulletin C4 of the Edison Electric Institute. This made possible continuous operation, even when burning Midwestern coal with high sulphur content, by maintaining minimum metal temperatures as shown in the drawing. Tests and actual experience have shown that elimination of low temperatures as


AIR INLET
Tie Pieces 1/16" x 1/8" steel flat, near top and bottom
(1)
Relatively larger surface exposed to air than to gas and other influences cause lower metal temperature than elsewhere in element.
Metal 200 F or Below
(2)
Clogging starts here, and is accumulative because gas side of metal is insulated and metal temperature reduces still farther.
(3)
Finally, entire gas passage in first section is clogged. Air flow continues, however, causing metal temperature to become still lower.
(4)
These second gas spaces clog after first gas spaces become clogged, due to low metal temperature from first gas space. When third gas spaces clog, pressure drop through air heater becomes too high, (50% clogged) and cleaning is necessary.
(5)
INSULATION IS APPLIED TO INCREASE METAL TEMPERATURE
Fill 0.065" (16 gage) channel with moistened 85% magnesia and push onto angle before hardening.
If channels are shaped to form Venturis as shown, and evenly spaced, pressure loss is nil.
350 F Gas Outlet
250 F Metal
3/8"
1/2"
3/8"
Spacers

Applying insulation to correct air heater clogging

the inlet end of the plates by application of this insulation has prevented the initial clogging in the joints, which, if permitted to start, would gradually extend across the bottom of the heater. In this case 210 deg. F. appeared to be the critical temperature below which hygroscopic sulphur deposits occurred.

THE POSSIBILITY that metals now considered rare may within the near future be used in large quantities by industry and trade was presented before the American Institute of Mining and Metallurgical Engineers by Paul M. Tyler, chief engineer of the Metals and Non-metals Division of the U. S. Bureau of Mines. Mr. Tyler pointed out that at the beginning of the present century ordinary industrial needs were supplied by about a dozen metals. Even nickel, cobalt, mercury and bismuth were used only in small amounts and aluminum was just beginning to progress beyond its former status as a jeweler's metal, he said. "Since then the number of metals in active use has more than doubled and research still proceeds."

Courts Demand Modern Equipment

Failure of Electric Company to Equip Power Wire with Ground Detector Is Negligence

By LESLIE CHILDS

COURTS have held that electrical companies are in duty bound to keep abreast of the times, in installing safety equipment for the protection of the public in the operation of power and light plants. And further, that a disregard of this duty which results in injury to an innocent party may render the company liable in damages on the ground of negligence.

Obviously, here is a point of importance for power and light plant executives charged with the duty of seeing that their operating equipment is kept up to date. And, as an illustration of judicial reasoning thereon and the possible danger to a light and power company in overlooking modernization, the following case is squarely in point.

Ground Detector Fails to Work

In this case the defendant was engaged in the light and power business and operated a high-powered wire along a public highway, carrying 2300 v. of electricity. This particular wire broke, and for a period of about 30 hr. the defendant was unaware of the accident until plaintiff's son, who was about 12 yr. of age, came in contact with it and was killed. The instant action for damages followed.

In defense, the defendant set up contributory negligence of the boy, and in addition that it maintained a proper safety device for cutting off the power in case the wire broke. Its explanation of the fact that it had no notice of the break was that the wire fell upon a fence which prevented the wire from grounding and thus giving notice of the break.

This evidence was, however, overbalanced by the testimony of several witnesses to the effect that had the defendant's line been equipped with a proper safety device notice of the break would have been given, since the wire was grounded before the death of the boy. On the evidence as outlined the trial resulted in a judgment for plaintiff in the sum of $10,000. On appeal the higher court in reviewing the evidence, in respect to whether or not defendant had properly guarded the wire, reasoned as follows:

"Defendant's contention that its wire was equipped with a proper safety device for cutting off the power in case of a break, and that it maintained a proper inspection service, is not supported by the evidence. * * * The evidence shows that during the evening of the day the wire broke a cow came in contact with it on the fence and was knocked down by the current. The contact with the cow constituted a grounding, and if the safety device had been working the current would have thereby been cut off. * * *

"It is therefore established that defendant's wire was not equipped with a safety device, capable of cutting off the power and giving it notice when a break occurred. It is reasonable to conclude that if defendant's wire had been equipped, as should have been done, with an efficient safety device, the life of plaintiff's son would have been saved. * * * "

Then, in stating the general rule of care required of electric companies in the operation of power wires, the court continued:

"The courts of this state recognize as the duty of electric companies maintaining high-powered wires in communities where contact may be had with the people engaged in the pursuit of business or pleasure in a legitimate way and in a place where they have a right to be, that of the utmost care consistent with the practical operation of their plant. * * * "

The court next directed its attention to the application of the foregoing rule to the facts of the instant case, and in this connection, in part, said:

"In this case it was defendant's duty to have its wire equipped with an efficient safety device, one that would work, cut off the power and render the wire

harmless in case it broke and fell, as it did do, near a frequently used highway and near enough the ground to be taken hold of by children not appreciative of the consequences of doing so.

"It was negligence of the gravest kind for the defendant to have left itself without knowledge of the existence of a danger thus created, for the period of time it is shown to have existed before it received notice of the same. Defendant's neglect in the way stated was the proximate cause of the death of plaintiff's son. The death and plaintiff's resulting damages is the direct consequence of defendant's neglect in the way mentioned. * * * " (132 So. 272)

In conclusion, the court, however, held the judgment of $10,000 to be excessive, and reduced it to $6000. And, as so amended it was affirmed, with defendant to pay the costs in the lower court and plaintiff to pay same on appeal.

To Sum Up

So that was that. And as an illustration of the possible danger to a power and light company in operating without, or with defective or antiquated, safety equipment this case is hard to beat. For while, of course, not infrequently accidents of this character will happen even in the operation of the most efficiently equipped plants, yet this in no way detracts from the importance of taking every reasonable means of precaution in accordance with the existing state of science and the art in question.

Otherwise, as is the case reviewed, in the event of an accident, that can be tied with a failure to use proper safety equipment, an electric company may, to say the least, be placed in a position very difficult to defend successfully. Truly, in the light of the facts and holding of the foregoing case it is one that may well be had in mind by electric power and light executives, charged with responsibility in the matter of purchasing safety equipment for their plants.

Practical Hints *on* Water Cooled Bearings

By Mark Bell

WHEN NEW auxiliary machinery is installed, it quite often devolves upon the engineers to hook up the bearing cooling water system. Whoever has this duty to perform has the opportunity of doing it in a sensible way, which will assist operation, or vice versa. Occasionally the system is hooked up with little regard to future ease of operation and a little care will obviate this. The whole idea should be to have the machine instantly available and, to safeguard this, the fewer valves that need opening or closing, the better.

Assume a multistage centrifugal boiler feed pump driven by a steam turbine. There will, usually, be six points to hook up for cooling water, viz.: two turbine bearings, two pump bearings and two lantern glands. Brass pipe and fittings should be used as the extra initial expense will be offset by the years of trouble free service. At each cooling point use a brass cock in place of a valve. These cocks can be set to give the requisite flow of water and cost less than valves. Use only one valve on the line and place this as near the steam throttle valve as possible. This one brass valve will act as a master valve and will operate wide open. If the lines are hooked up in this way the operator can start his pump with a minimum of effort and lost motion as the steam valve and water valve are close to his hand. He will have no cooling water adjustment to take care of as the cocks will be set and only the one valve will need to be opened, and that one, wide.

Whilst on the subject of cooling bearings it is as well to watch for another point. Choose a bearing that has a water cooling passage which takes in the cap as well as the bottom half. If a bearing is chosen which only provides a water passage in the bottom half you will have frequent trouble as the top half can get hot enough to run whilst, at the same time, the bottom half remains cool. This will not be apparent when the pump is new and the steam seal glands are quite tight but, when they begin to leak and when it is not convenient to shut down at once, hot bearings will ensue and the trouble will start in the top, uncooled half.

Do not be sold on any cooling system such as a pipe with fins like a radiator which is immersed in the oil well. They are very good in theory but most unsatisfactory in practice and do not, adequately, carry off the heat. If the design of the machine is such that water cooling is installed see that it is a real, water cooled bearing that is used and save yourself worry and trouble later.

Make sure that the oil ring is as wide as possible. The more oil circulated, the better the cooling and the safer the operation and insistence on this, apparently trivial, detail at the time of purchase will repay the effort.

Do not believe that, just because the maker offers a machine which, to your way of thinking, has one or more of these undesirable features, it must be all right because he is the maker. He may really believe the design is right and it may have acted well on the test block when the gland seal rings were tight and other considerations favorable. In a hot, often dusty basement where feed pumps are usually installed conditions are far different and continuous operation will show up weaknesses.

Machines have been delivered, apparently O. K. and after several months during which continual trouble with the bearings was encountered, the maker has been compelled to replace the bearings with a better design at his own expense. Even further adjustments have been made in the form of wider rings before the equipment was fairly satisfactory.

Changes such as the above, even when made at the manufacturer's expense, are costly to the operator, as changing over and getting the schedule out of gear entails considerable expense.

Is it not better to go fully into these matters at the start and then, when your new equipment is installed, you can go right ahead without costly and bothersome adjustment and repairs and, possibly, shutdowns?

As One Engineer to Another—

Some of the Laws of Vapor and Air Take on New Meaning as the Chief and His Friend Chat and Figure

By G. F. WETZEL

NOT HAVING heard from or seen my friend, the Chief Engineer for quite a while, I thought it was about time to get in touch with him again, so I dropped into his office for a chat.

"Hello, G. F.," he greeted me. "I thought maybe you had retired to live on the interest of your debts, and had forgotten all your old friends."

"Nothing like that, Chief, I value my friends too highly to forget them, even if I ever should be fortunate enough to be able to retire. Any special problems on your mind?"

"I don't happen to have any particular questions of my own just now, but maybe you could settle an argument. The other night at our association meeting, one of the boys, in talking over the action of steam, made the statement that air and steam do not mix, and I said that they do. Wasn't I right?"

"You were correct, Chief, and your boy friend was also right. On the other hand you were both wrong."

"What do you mean, we were both right and both wrong?" the Chief questioned.

"You will recall from our previous discussion that there is really no difference between water vapor and steam, though the conventional understanding is that vapor exists below 212 deg. and below atmospheric pressure, while steam is saturated water vapor above 212 deg. temperature and with a pressure of more than 14.7 lb. per sq. in. absolute.

Dalton's Law

"One of the laws which will help you understand vapor-air mixtures is known as Dalton's Law. This law is, in a mixture of gases, or vapors and gases, each constituent exerts the same pressure that it would exert if by itself with the same volume and temperature, the total pressure of the mixture being equal to the sum of the individual or partial pressures. Put in equation form:

$$P = P_1 + P_2 + P_3$$

where P is the total pressure, and P_1, P_2, P_3, etc., are the respective pressures of the vapors or gases making up the mixture.

"Suppose we had a closed vessel, containing a mixture of saturated water vapor and air, with the pressure 14.7 lb. abs. and temperature 70 deg. What would be the pressure of the air in the vessel?"

At the question, the Chief began to sit up and take notice. "What was that law you were talking about, G. F.?"

I repeated the law for him.

"I get it now," he exclaimed. "The pressure of the air plus the pressure of the water vapor is 14.7 lb. abs. If you know the pressure of either one, you can find the pressure of the other. Wouldn't the pressure of the water vapor be given in the steam tables? Of course it would!" he answered his own question, and reached for his book containing steam tables. "At 70 deg. the vapor pressure would be 0.3626 lb. abs., which would leave 14.34 lb. abs. for the air pressure."

"Suppose we had our closed vessel filled with a mixture of saturated water and vapor and air at 150 deg. and at atmospheric pressure, 14.70 lbs. abs. What would be the air pressure?" I continued.

"Really, G. F., this is too easy for an accomplished 'steamologist' like me. The steam table says 3.714 lbs. abs. for saturated vapor at 150 deg. and, therefore, the air pressure must be the difference between 14.70 and 3.714 or 10.986 lb. abs. Say, I just got an idea," he exclaimed. "The steam sets up the pressure corresponding to its temperature, and the air takes what is left!"

"That proves you are a 'steamologist,' Chief. A lot more could be said if I were inclined to be sarcastic. But your idea is correct. Even though the vapor is not saturated, it still has the pressure corresponding to its temperature and superheat, or its relative humidity, or its dew point. To continue, let us have our suppositious vessel filled with saturated steam and air at 212 deg. and atmospheric pressure."

"I don't have to look in the book for that," he answered. "The steam pressure will be 14.7 lb. abs. and the air pressure will be what is left which is—nothing—or if there is any air present it will have the same pressure as the steam, and will not mix with it but be perfectly dry. I see what you are driving at now, G. F., and I guess our argument at the association is settled. Where the total pressure is atmospheric and the vapor pressure is less than atmospheric, vapor and air will mix, but when the steam pressure is as great as the total pressure naturally the air pressure will be zero, and there being no air pressure there can be no air mixed with the steam, and of course no mixture. Okay, G. F., give me something hard."

Boyle's Law

"All this will be easy for you, Chief, just follow it through. Another law which applies to gases, and which you may have heard of at one time or another, is known as Boyle's Law, and states that for perfect gases, if we hold temperature constant, the pressure of a given weight of gas will vary inversely as the volume changes, the product of V (specific volume) and

P (pressure absolute) being constant for any given temperature. Thus if t (temperature F) is constant PV = C. Put it in figures and it will look like this: t = 70 F. (for example), P = 14.7 lb. abs., V = 13.35 cu. ft. (being the number of cu. ft. per lb. at 70 F. and 14.7 lb. abs.).

$$14.7 \times 13.35 = C = 196.245$$

"Now, as long as the temperature is kept at 70 F. you can take any pressure you like and find the volume one pound of gas will occupy at that pressure. For example: P — 50 lb. abs., solve for V: 50 V = 196.245

$$V = 196.245/50 = 3.925 \text{ cu. ft. per lb.}$$

Of course, for every different temperature there will be a different constant, but the important thing to remember about Boyle's Law is that pressure and temperature vary inversely, as either one gets larger the other will get proportionately smaller, and vice versa.

The Law of Charles

"The last gas law I am going to inflict on you is Charles' Law. In 1787, a French scientist found that a gas increased in volume a constant proportion of its volume at the freezing point, for each degree increase in temperature. In other words, when the temperature of a gas changes, the volume of a unit weight changes 1/492 of its freezing point volume for each degree F. of temperature change. You will remember that 492 (or to be more accurate 491.6) is the number of Fahrenheit degrees below the freezing point of water to give us absolute zero, or 460 deg. below 0 F. Therefore, the volume of gas at constant pressure is proportional to its absolute temperature.

"Combining Boyle's Law and Charles' Law we arrive at the general gas law PV = RT or as it is more conveniently written:

$$\frac{PV}{T} = R$$

where P is absolute pressure, V is volume per pound, and T is absolute temperature, R is a constant which does not change with temperature, but is different for different gases, the one we are interested in being for air. Now this is the important gas law that you should know and be able to apply. Stated in words the law is this: With pressure constant the specific volume of a gas varies directly as the absolute temperature changes, and with volume constant the absolute pressure changes directly as the absolute temperature changes. Using the figures we used before to illustrate Boyle's Law we will work out the constant for air:

$$\frac{14.7 \times 13.35}{(460 + 70)} = \frac{14.7 \times 13.35}{530} = 0.3703$$

where P is absolute pressure in pounds per square inch
V is volume in cubic feet per pound
T is absolute temperature F. degrees.

"Note that 'T' is usually the symbol for absolute temperature, and 't' the symbol for Fahrenheit degree starting from 32 deg. below the freezing point of water. Steam or water vapor at the very low pressures found in atmospheric humidity, follow substantially the gas law just mentioned, in that specific volumes, pressures, and specific weights (or weights per cubic foot) respectively will change in proportion to absolute temperature changes, the other condition (P or V as the case may be) remaining constant."

"I suppose that is all very true, G. F." the Chief said, "but give me some reasons for burdening my brain with it, and some examples of how you could apply it."

"The reasons you ought to know about these things are that they explain the mixture of steam and air in a condenser, will help you to understand the true significance of humidity, will enable you to calculate the specific volume and weight per cubic foot of partially or fully saturated air, and understand why compressing air removes water from the air, among other things."

"Now, for illustrations: Suppose in a condenser the vacuum gage showed 28 in. vacuum and the thermometer gave a temperature of 95 deg. F. Look in your steam tables and see what story you can make out of those figures."

The Chief looked at me with a questioning expression on his face as if he was not quite sure what he was up against. But he reached for his steam table book and looked on the correct page.

"28 in. vacuum is 29.92 — 28, or 1.92 in. of mercury pressure," he figured, "And the temperature corresponding to that is 100 deg. F. But listen, G. F., you said the temperature was 95 deg. F. How come?"

"Listen yourself, Chief. I asked you what story you could make out of the figures I gave you. Can't you take a hint? Suppose you look at the pressure corresponding to 95 deg. F. instead of the temperature corresponding to 28 in. of vacuum," I told him.

"95 deg. F. has a pressure of 1.65 in. of mercury pressure. Now I see what you are driving at. The difference between 1.92 and 1.65 is the air pressure or 0.27 in. mercury," he said. "And I guess that must be an application of Dalton's Law of Partial Pressures. The total pressure is 1.92 in. made up of 1.65 in. of steam pressure and 0.27 in. of air pressure. I certainly am glad that you got me clear on pressures, vacuums, etc., last time."

"Right, Chief. Now go ahead and figure the specific volume of the air. Use the PV/T = 0.3703 equation and remember that 1 lb. per sq. in. is equivalent to 2.03 in. of mercury."

This was a somewhat new line of reasoning to him, so he stopped to think about it, then took up his pencil and put down some figures. In a few minutes he showed me his paper.

PV/T = 0.3703 where P is abs. press. in lb.
= 0.3703 × 2.03 = 0.7517 where P is press. in inches of mercury

$$V = \frac{0.7517 \times T}{P} = \frac{0.7517 \times (460 + 95)}{0.27}$$

= 1545.13 cu. ft. per lb.

"Atmospheric air at 95 F." he referred to another table, "is 13.98 cu. ft. per lb. So with 1545.13 cu. ft. per lb. it would be pretty thin air, which of course is what you would expect in a condenser. Also I can see now that if conditions were as you gave them the air could not be separated from the steam as they would be present as a mixture."

"The old brain is now functioning I see, Chief," I told him. "Under certain conditions we might have the temperature and pressure as given and if so the

specific volume of the dry air would be what you figured. To carry this on further, consider that the temperature and pressure in the condenser are 95 F. and 28 in. vacuum, and there is some air present. Show me mathematically where the air should be taken off from the condenser."

"I see," he replied, "you want me to figure the weight per cubic foot of the air and steam to see which is the lightest. The air and steam won't mix because the steam will be saturated, with temperature and pressure corresponding, and the air will be at just about the same temperature and pressure. The steam will have a pressure of 1.65 in. of mercury. The steam table gives a density or specific weight of 0.00247 lb. per cu. ft. and 405 cu. ft. to the pound. The volume of one pound of air will be . . . ," and he put down the figures:

$$PV/T = 0.7517$$

$$V = \frac{0.7517 \times T}{P} = \frac{0.7517 \times (460 + 95)}{1.65}$$

$$= \frac{0.75171 \times .555}{1.65} = 252.84 \text{ cu. ft. per lb.}$$

"Wt. per cubic foot = 1/252.84 = 0.00396 lb. per cu. ft. 0.00396 lb. is heavier than 0.00247 lb. per cu. ft. of steam, therefore the air will be heavier and will be taken off at the bottom."

"Well, Chief, my time is up, and I must run along. Will you forgive me now for thrusting those laws of Dalton, Charles, and Boyle down your unwilling throat."

"I'll tell the world," was his reply.

Wood Waste Fuel *for* Small Plant

Fuel conveying and automatic combustion system give excellent service up to 125 per cent load on boilers

By Fred S. Rutledge

AN ARRANGEMENT for conveying and burning the shavings and sawdust made in a wood working shop which employs only one fan to convey the fuel and furnish forced draft for the furnaces under the boilers has been in satisfactory service for a number of years. Figure 1 shows the front elevation of the boilers and Fig. 2 the side. The exhaust fan, located about 80 ft. from the cyclone or dust collector, with 42 in. casing, 36 in. discharge, direct connected through flexible coupling to 15-hp., 1200 r.p.m. induction motor and took all the refuse from the wood working machines and delivered to the dust collector.

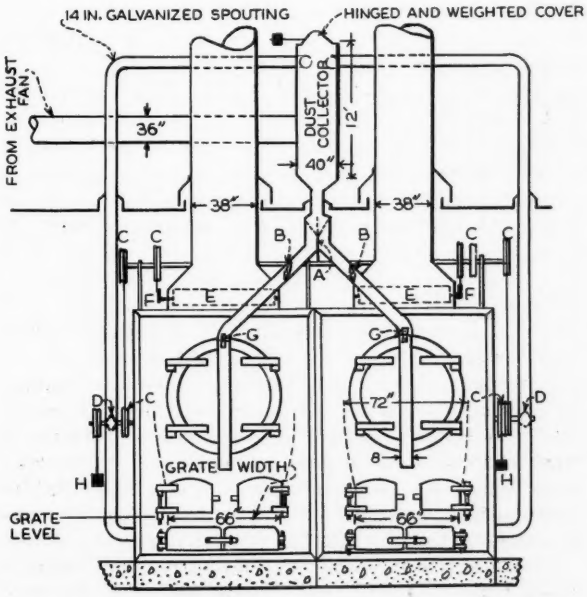


Fig. 1. Front elevation of sawdust burning boilers

This dust collector was made by a local tin shop and I do not believe there ever was another one like it. The dimensions are 40 in. dia., length, 12 ft. On the top is a cover having an arm fastened to it with an adjustable weight on the arm. Opposite the weight arm is a large strap hinge, fastened to the cover and the other end to the body of the dust collector. The object of this will appear later. From the bottom, the refuse was discharged through spouts which delivered above the fire doors and to the grates in line with the center of the boiler.

Near the top of the cyclone, two 14-in. galvanized sheet iron spouts are connected, one for each boiler, and carried down to the ash pits. A is a damper or switch by means of which the shavings may be fed to either boiler or both. Back fire dampers are located at B. At points marked C are pulleys or shives for the chains which connect them to operate stack dampers, E, and blast spout dampers D. F-F are levers to operate stack dampers E-E. G-G are hinged joints so that the shaving spouts may be swung up out of the way when flue doors need to be opened.

H, Fig. 2, is the damper regulator which is set for the steam pressure required and operates all dampers, controlling the stack draft and forced draft. This regulator is extremely sensitive and quick in operation.

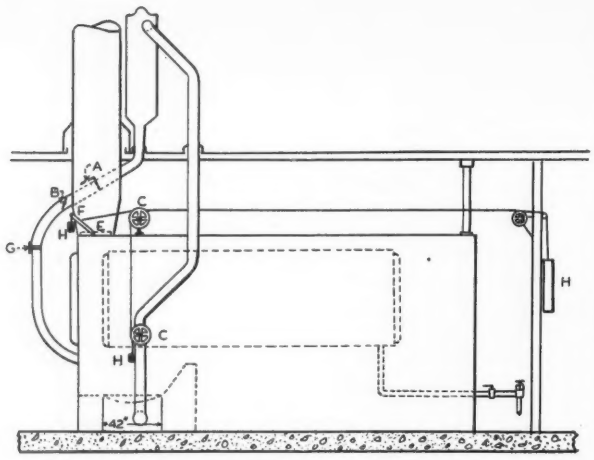


Fig. 2. Side elevation of boiler showing duct arrangement

Electricity is the controlling agency and water, at 75 lb. pressure, the operating power. Figure 3 shows the layout of the regulator and Fig. 4 the valves for supply and discharge of the water to and from the plunger.

The operation of the whole is as follows: If the steam goes below the predetermined pressure the electric contact at D, Fig. 3, is broken, allowing magnet coil lever C to drop away from magnets. This causes valve A to seat, shutting off water supply and opens valve B, allowing the water in the barrel E above the plunger to escape through free drain F. The weights H, Figs. 1 and 2, pull all dampers open allowing more stack damper opening and increasing forced draft pressure under the grates. It takes only a slight variation in pressure to cause this regulator to operate, as the governing element of operation is the spring in the electric contact gage. This is not a step regulator but a wide open-tight shut type, but I have seen it

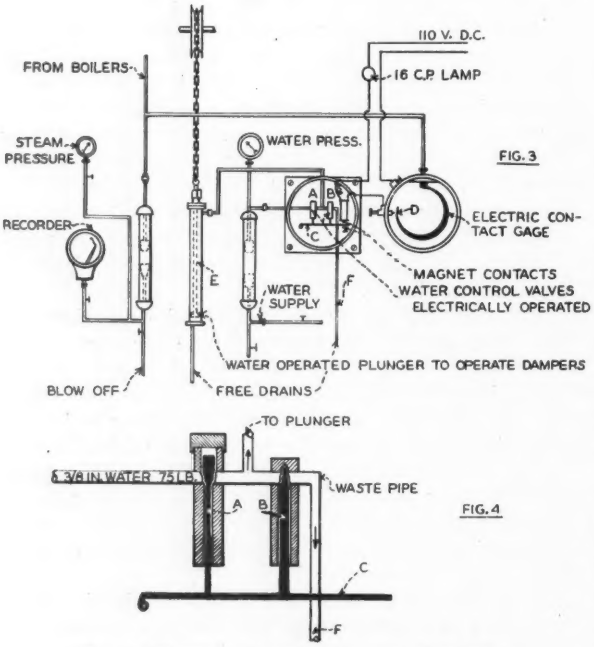


Fig. 3. Diagram of combustion control system
Fig. 4. Detail of electrically operated control valves

play on a travel of not over 1½ in. on the pluger rod for 1½ to 2 hr. when the shavings were running steadily.

When the steam pressure rises high enough to make contact at D, Fig. 3, the magnet pulls up the bar or lever C, Figs. 3 and 4, opening valve A and shutting valve B, the pressure of the water acting on the plunger and shutting all dampers. Here is where the cover on top of the cyclone or dust collector begins to do its little bit. With the dampers D in spouts to ash pits shut, the weighted cover opens slightly and relieves the pressure, but still maintains enough to send the shavings into the furnace. This took a little experimenting, as with no pressure in the cyclone the shavings would plug up in the spouts going to the furnace and with too much pressure the load on the motor driving the exhaust fan became too heavy and the motor would heat up unduly.

Where the shaving spouts go into the boiler fronts there are cast-iron forms built into the brick work. The spouts were formed from round to rectangular, beginning just above the hinged joint G and worked down to a thickness of 5 in. and a width of 10 in. where they enter the cast forms. These cast forms are made in halves, upper and lower, and have an arrangement

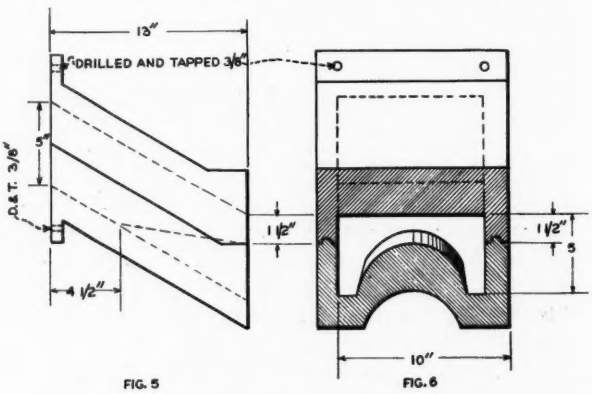


Fig. 5. Side elevation of cast-iron fuel spout
Fig. 6. End view of cast-iron spout

called a spreader cast on the bottom half, that spreads the shavings pretty evenly on the grate. If the discharge of shavings and sawdust is not too heavy, they are all burned in suspension.

The grates are 66 in. wide, 42 in. from front wall to bridge wall and 42 in. from grate to shell of boiler. Figures 5 and 6 show side and end sketches of cast spout that goes through boiler front. The angle from the horizontal is such that the bottom of the spout lines up about 2 in. above the grate line, at bridge wall. The whole arrangement seems to operate efficiently and has saved money in labor since installed.

One improvement that seems desirable, however, is to increase the furnace volume by lowering and lengthening the grates, as on heavy loads the fire has to be carried so heavy that shavings only partially burned are carried up the smoke stack and quite a lot of smoke is made. Below 125 per cent of rating they get along very nicely. If there are not enough shavings or sawdust made to supply the demand for fuel anything combustible on this kind of grate may be fired through the doors in the regular way.

Air Conditioning *centers in* Chicago

Annual Convention of the A.S.H. & V.E., N.W.A. & A.C.A. and Heating & Ventilating Show Held Concurrently

RIDING HIGH on the tide of prosperity, air conditioning held the center of the stage in Chicago during the week of January 27-31. Two national conventions and an exhibition of new equipment centered around this important topic, even though the weatherman took a hand and produced a subzero wave as a forceful reminder that, although comfort cooling may be news to John Public, heating is still the major problem of the industry.

Chicago may be considered the birth place as well as the modern center of comfort cooling. The Congress Hotel installation antedated by several months the much publicized New York Stock Exchange installation and at the present time there are something like a thousand air conditioned installations totaling perhaps 50,000 hp. This is said to be the largest number in any city of the world and includes all types.

A. S. H. & V. E.

Recent importance of air conditioning to the industry is well reflected by the optimistic tone of the 42nd Annual Meeting of the American Society of Heating and Ventilating Engineers held at the Palmer House. Under the able direction of John Howatt, chief engineer of the Chicago Board of Education, the financial condition of the Association improved to such an extent that the 1933 and 1934 transactions will soon be published; cash is available for the immediate production of the 1936 issue of the Guide and prospects are bright for the full resumption of the research activities. Some 200 new members brought the membership to well over the 2000 mark and the membership committee faces the problem of limiting further increase so as to promote a healthy growth free from ills that often follow abnormal expansion.

A registration of over 1200 (topping the 1930 record at Philadelphia) at the convention and nearly as many at the banquet on Wednesday evening, testifies to the importance attached to air conditioning by the engineering profession. At this banquet President Howatt's address was broadcast over the N.B.C. system and later at this banquet Dr. Arthur Cutts Willard, president and former dean of engineering at the University of Illinois, was presented with the F. Paul Anderson Medal for his work with the Association. Dr. Willard has been active in the Society since 1914, has held many offices including that of director of research and president (1928), and the citation was made for his "outstanding work as engineer, teacher and author in the field of heating, ventilating and air conditioning; for his outstanding service as consultant on the ventilation of the Holland Tunnel, the United States Capitol and proposed Chicago subway; for his outstanding work in research and for the service he rendered to the Society as a member, as an officer and as a technical advisor to its committee on research."

This medal, made possible by the grant of another past president, Thornton Lewis (1929), commemorates F. Paul Anderson, past president of the Society (1927), active in its affairs and dean of engineering at the University of Kentucky until his death a few years ago. The presentation was made by President Howatt, and immediately afterward H. T. Richardson, as president of the N.W.A. & A.C.A., gave Dr. Willard an electric clock and barometer as a token of appreciation of his work with the latter society.

Technical Papers

Four technical sessions were held during the convention, the first being largely a business meeting with reports of various committees. A. P. Kratz, Chairman of the Committee on Research, outlined the 16 research projects now under way at the Research Laboratory and at various co-operating universities. These projects deal with cooling standards, air conditioning in the treatment of disease, dust removal and collection, corrosion, direct and indirect radiation, frictional resistance of ducts and fittings, heat requirements of buildings and heat transfer of finned tubes. During the past year 11 technical papers were presented dealing with research carried on by the Committee.

Another committee report of some importance to the industry was presented by W. E. Stark, Chairman of the Joint Committee on rating commercial refrigerating equipment. These proposed standards were discussed at considerable length and when completed should do much to standardize equipment used in the air conditioning field.

A number of other papers were related to the general subject of air conditioning and ventilation with particular reference to comfort standards. C. E. A. Winslow and L. P. Herrington of the John B. Pierce Laboratory of Hygiene, New Haven, Conn., presented the results of a study of outdoor weather conditions made up from questionnaires over a long period of time from many people. Results are not conclusive but the judgment of these people in regard to the pleasantness of outdoor atmospheric conditions is chiefly influenced by sunshine, relative humidity and total ions in the air. The influence of ions is not related to the electrical

charge, since positive and negative ions show identical results, and, the authors are inclined to explain the negative effect of these as the result of products of combustion which make up a large portion of the ions in a city environment.

Ventilation Requirements

More specific were the results of indoor conditions presented by C. P. Yaglou, E. C. Riley and D. I. Coggins of the Department of Industrial Hygiene, School of Public Health of Boston. This was one of the research projects sponsored by the Society and showed that the ventilation requirements, particularly for the removal of objectionable odors in closed spaces, varied with the type of occupants and with the air space per person. It was found that even after a bath a healthy, clean person gave off an appreciable odor which required from 15 to 18 c.f.m. of outdoor air per person in order to dilute it to a concentration not objectionable to people entering the room from relatively clean air. A week after a bath the ventilation requirements of children increased from 18 to 29 c.f.m. as compared with an increase of from 15 to 20 in the case of adults.

Concentration of CO_2 in the air of occupied rooms proved to be an unreliable index of ventilation and the usual process of washing, cooling and dehumidifying recirculated air removed a considerable amount of body odor under certain conditions, sprays with fresh water removing practically the maximum amount possible. Discussion following this paper showed that ventilation requirements in general should be considerably increased in order to come up to the standards set by the authors.

Another paper of more than usual interest was Comfort Standards for Summer Air Conditioning, by F. C. Houghten and Carl Gutberlet of the A.S.H. & V.E. Research Laboratory. As a result of the limited amount of work done, it is evident that the comfort zone can be extended considerably by proper control of temperature and humidity conditions and that very high humidities can be carried without discomfort if proper temperatures are maintained. It is also probable that the temperature differential between inside and outside temperatures, considered so important in air conditioning, are really of minor importance and further studies will throw light on factors which will make it possible to greatly increase this differential if desired. Conclusions reached by the authors are as follows:

Time Delay

The study indicates rather conclusively that the average person will become comfortable within from 20 to 40 min. after entering any atmospheric condition within an effective temperature range of 70 or 71 deg. to 74 or 75 deg. Within this range no appreciable variation was observed in the magnitude or the duration of the cooling shock with either the relative humidity of the cooled condition or the severity of the previous condition. Also, little variation in the rate of disappearance of sensible perspiration was observed for relative humidities up to 65 per cent; for relative humidities as high as 85 per cent there seems to be some increase in the length of time necessary for the complete disappearance of sensible perspiration.

Another research project sponsored by the Society was reported upon by R. R. Seeber, F. A. Rohrman and G. E. Smedberg of Michigan College of Mining and Technology, Houghton, Mich. This dealt with corrosion in steam heating systems and among other conclusions the authors decided that the other factors being constant, the corrosion rate will vary directly with CO_2 in the condensate at least up to about 30 parts per million. One part per million of oxygen appears to have the same corrosive effect as 20 to 30 parts per million CO_2. Increase of temperature for the same pressure increases the corrosion rate up to a certain point but from there it decreases rapidly with further increase of temperature. Increased rate of flow of condensate increases corrosive effect. A decrease in pressure carried in the system for the same quantity of steam decreases the corrosion rate in a tight system.

G. L. Tuve of the Case School of Applied Science reported another research project dealing with the performance of fin-tube units. Data is lacking to develop a test code as yet but tests indicate that reasonably accurate performance tables may be built on the basis of a few simple straight line graphs of overall heat transfer coefficients plotted against air velocity. Any arrangement which increases the local eddies in the air stream will increase the heat transfer especially at the higher velocities. For maximum heat transfer the fin-tubes should be placed as close together as possible without interlocking.

Frost on Windows

A closely related paper by W. A. Rowe of Detroit, Mich., dealt with the airfoil fan characteristics, a special type of propeller exhaust fan developed by the author to give high efficiencies for specific conditions. This is accomplished by setting the fan in the proper orifice and designing the blade tips to give the desired performance. A special variable pitch, variable angle propeller blade is used.

A number of papers dealt specifically with small home problems and A. P. Kratz and S. Konzo of the University of Illinois reported on the fuel saving resulting from the use of storm windows and doors at the research residence at Urbana. A fuel saving of approximately 20 per cent was estimated and the actual savings agree well with the calculated results. For a given type of wall construction the fuel saving is dependent upon the ratio of the area of the windows and doors to the net area of the walls with a potential saving increasing with this ratio.

Experimental results of tests made at the University of Michigan and reported upon by J. E. Emswiler of the University and W. C. Randall of the Detroit Steel Products Co., were made to show the room surface temperature of glass in windows. This work was done by means of a warm box and a cold box in opposite sides of the windows and in still air for single windows it was determined that about 50 per cent of the heat drop took place in the glass and for double windows about 25 per cent. Moving air increased these values somewhat. Results of these studies were presented to assist in the calculation of the temperature and humidity conditions at which frost would form on double and single windows. Discussion brought out

the fact that the same results might have been arrived at by using the heat transfer coefficients already available.

Burton E. Shaw of the Penn Electric Switch Co., Des Moines, Ia., gave the results of a lengthy study of different types of thermostats which for reference purposes were placed in three groups—a short cycle of ¼ deg. F., a medium cycle of from one to two degrees and a long cycle of 2 deg. F. or over. Results were plotted in graphic form and there appeared to be little difference in economy between the various types. Also from the viewpoint of economy, there is little difference between a 30 in. thermostat mounting and a 5 ft. mounting but from the standpoint of comfort the 30 in. is preferable. The slight difference in economy of the long over the short cycle thermostat was reported as being due to higher stack temperatures during the off period and the author reached the conclusion that short cycle operation would be preferable from both comfort and economy standpoints if present designs permitted more control of off period losses.

Report of the work on the room surface temperature of glass in windows was presented at the joint session between the Society and the National Warm Air Heating and Air Conditioning Association. At this same session S. Konzo reported on the results of cooling the research residence at Urbana, Ill., by means of cold water taken from the city mains. Previous reports had covered the cooling of this residence with ice and with mechanical refrigeration.

New officers of the A.S.H. & V.E. during the coming year include the following: President, Prof. G. L. Larson, Department of Mechanical Engineering, University of Wisconsin, Madison, Wis.; first vice president, D. S. Boyden, Supt. Steam Heating Service Dept., Edison Electric Illuminating Co., Boston, Mass.; second vice president, E. H. Gurney, president, Gurney Foundry Co., Toronto, Ont.; treasurer, A. J. Offner, consulting engineer, New York, N. Y.; secretary, A. V. Hutchinson, New York, N. Y. Four new council members were elected as follows: R. C. Bolsinger, Automatic Florzone Heating Co., Conshohocken, Pa.; W. L. Fleisher, consulting engineer, New York, N. Y.; S. H. Downs, chief engineer, Clarage Fan Co., Kalamazoo, Mich.; C. M. Humphreys, Carnegie Institute of Technology, Pittsburgh, Pa.

N.W.A.H. & A.C.A.

For three days National Warm Air Heating & Air Conditioning Association held its 23rd Annual Convention at the Stevens Hotel. The program dealt largely with domestic problems including insulation, application of gas and installation codes. This organization is also active in the research field and carries on an extensive program each year under the direction of F. G. Sedgwick, chairman of the Research Advisory Committee, which coöperates closely with the A.S.H. & V.E. Officers for the coming year are as follows: president, W. L. Rybolt, Rybolt Heater Co., Ashland, Ohio; first vice president, L. R. Taylor, International Heater Co., Utica, N. Y.; second vice president, Dana W. Norris, Lennox Furnace Co., Syracuse, N. Y.; managing director and treasurer, Allen W. Williams, Columbus, Ohio. Newly elected directors, C. A. Olsen, Fox Furnace Co., Elyria, Ohio; Richard M. Judd, Premier Furnace Co., Dowagiac, Mich.; H. S. Sharp, Henry Furnace & Foundry Co., Cleveland, O.; H. P. Mueller, L. J. Mueller Furnace Co., Milwaukee, Wis., Shirley Percival, Green Foundry & Furnace Co., Des Moines, Iowa.

Equipment Exhibition

During the same week, the Heating Show, known officially as the Fourth International Heating & Ventilating Exposition, occupied two rooms of the International Amphitheater, Stock Yards, Chicago, and was proclaimed a huge success by the visitors and by the manufacturers. As might be expected from the name of the show and from the programs of the two conventions, the exhibition dealt largely with domestic heating and cooling, although much of this equipment is applicable to smaller industrial installations. Oil burners, gas burners and stokers of all types were represented and room coolers, combination heaters and coolers, water vapor refrigeration, compression refrigeration and steam jet refrigeration all occupied prominent places in the exhibits.

One of the unusual exhibits was that of a small pulverized coal furnace. Pulverized coal would be furnished to the owner and users in dust proof containers and ash would be removed by the same service organization that supplied the coal. The removal of dust and cinders from smoke, air and in various industrial processes is extremely important and the newest type of filter to be used for this purpose is a new by-product of the stock yards, chemically treated hair packed in a special container and which it is claimed gives a low pressure loss and high dust capacity. Dust collectors included a new electric precipitator, a recent development of the exhibitor and intended to remove dust, soot, pollen and other solid and liquid particles from air. It is stated that tests have proved this method of air cleaning will remove 99 per cent of all particles having a diameter larger than 40 millionths of an inch and is stated to be an effective solution of many dust collecting problems in industry.

Glass filters were also exhibited but were overshadowed by the small exhibit of glass cloth and thread which offers possibilities in the heat insulation line for temperatures of up to 1000 deg. F. and also for electrical insulation. This thread is as flexible as cotton and the coarse cloth exhibited, woven from these fibers, resembled heavy duck or canvas. Acoustic felt, its application to telephone booths and ducts was demonstrated by a working exhibit set up to show that the suction ducts transmits as much noise as discharge ducts although this noise may be eliminated from both by proper duct lining.

Power devices, power transmission equipment, motors, gears, instruments of all kinds, played their part in the show and one manufacturer exhibited a sump pump which operates without floats, floats being replaced by special electrodes which, short circuited by the water, start and stop the pump within the desired levels. Metal exhibits covered a variety of alloys and stainless steels and included a new line of electric welded boiler tubes with a special smooth blued finish for resisting corrosion particularly during storage.

As a conclusion to a busy week, about 200 visiting convention members spent Friday on an inspection trip to the Chicago works of the Crane Co., covering the various manufacturing processes.

Readers' Conference

Boiler Gage Glasses

FRACTURE of water gage glasses is not uncommon. This is seldom due to wear and tear but usually to an inferior glass being used or to improper fitting. In the first case good quality gage glasses should be used and a suitable washer fitted at either end. These should be of rubber with a ply of asbestos on either side. The two gage cocks must be in perfect alinement otherwise there will be a bending action on the glass which, however slight, may cause fracture of the glass.

There is also the expansion under the working temperature which will, if the glass is too tight in its gland, cause fracture. Glasses should not be fitted too tight. It should still be possible just to move the glass by means of the finger and thumb after the final tightening up. This may result in a slight steam leakage at first but this will correct itself as the packing swells.

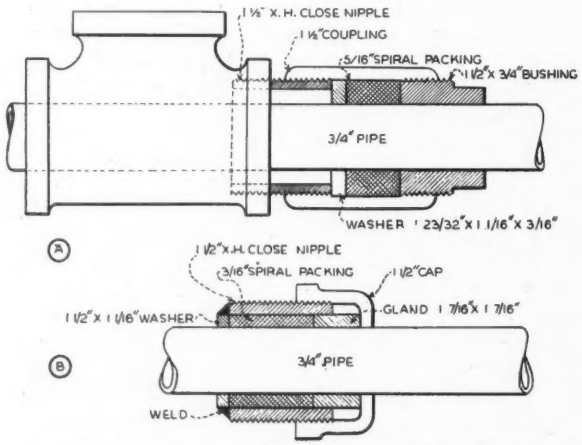
There is more expansion at the steam end owing to the higher temperature and therefore the glass should be slightly slacker in the gland here, than at the water end. This will allow for any increased expansion at this spot which might otherwise result in fracture.

Owing to the higher steam temperatures and pressures now common, the duty on these glasses is becoming more severe with the result that more careful attention is necessary.

Kent, England — W. E. WARNER.

Double-pipe Heat Exchanger

OCCASIONALLY there is need around the power plant for an inexpensive heat exchanger, either for cooling or for heating liquids such as oil or water. This can be made up in the form of a double-pipe heater or cooler from pipe and fittings of such dimensions as will best meet individual requirements.



Heat exchange made of pipe fittings (A) and improvement in stuffing box (B)

In making up such a device, the only difficulty that presents itself is in making a good tight joint where the inner pipe passes through the outer one and one that will not entail a great expense. A hot water cooler of this type that was made up and proved quite satisfactory, was made from 1½ and ¾-in. galvanized pipe and fittings with the gland made up as shown in the detailed sketch.

An extra heavy 1½-in. close nipple was screwed into the 1½-in. tee and to this a 1½-in. coupling; a washer was bored out to allow a ¾ in. pipe to pass through and its outside diameter turned so that it could be slipped inside the coupling and butt up against the end of the nipple; the stuffing box thus formed was filled with spiral packing and a 1½ by ¾-in. bushing which had been bored out so as to allow the ¾ in. pipe to slip through, was screwed into the end of the coupling with just enough pressure to stop any leakage.

Subsequently a much neater type of stuffing box was devised by welding a washer to the end of an extra heavy close nipple and using a 1½-in. cap drilled to allow the ¾-in. pipe to pass through and a gland bored and turned from a piece of tubing to compress the packing into place.

Clyde, N. Y. — JULIUS BRODSKY.

Belt Flopping Over on Pulleys

REFERRING to the article by John E. Hyler, page 587, in the October number of Power Plant Engineering, a belt that is "turned over" in the manner described by Mr. Hyler has one important advantage which he does not mention, namely, the slip is always in one direction on the belt's surface. That is, there is no reversal of direction of slip.

For instance, if it is a single ply belt, the rough or flesh side of the belt comes in contact with one pulley and the smooth or hair side makes contact solely with the other pulley. For this reason slip is always in the same direction and any projecting fibers will always be smoothed down in the same direction. As a result there will be less wear.

Belt manufacturers and users will agree that a piece of leather or other fibrous material can be worn down more quickly by rubbing it "back and forth" than by constantly rubbing it in the same direction. When a carpenter sandpapers a piece of wood he rubs the paper "back and forth" over the wood in every direction, because he finds the wood will smooth down better and more quickly in that way.

Belts as ordinarily placed on pulleys are subject to this "back and forth" rubbing, because all belts creep and some of them slip. If the life of a belt can be lengthened by giving it a twist, the belt should by

all means be twisted if the conditions of the drive are such that it can be done without impairing transmission.

Belts always creep toward the tight side. They must creep that way. There is nothing else for them to do so long as they possess elasticity. All belts, even steel, are elastic. That being the case, let us trace the action of the projecting fibers of any belt as usually operated. As the belt comes into contact with the driver pulley the fibers are leaning over and pointing "from" the drive because that is the way they were "rubbed" by the driven pulley which they just left. Immediately upon touching the driver pulley the fibers now find that the belt is creeping toward the tight side in opposition to the direction of rotation of the driver pulley. At a certain point, therefore, a turning point occurs and soon thereafter the fibers are smoothed over in a direction opposite to that in which they approach the driver.

The fibers now rush over to the driven pulley with an antagonistic slope pointing "toward" that pulley. Upon touching the driven pulley these fibers find that the belt is traveling faster than the driven pulley because creep is again toward the tight side, and at another certain point we have another turning point where the fibers are combed, bent, or rubbed back to the original position. Then the fibers dash over to the driver pulley once more and they are again reversed. And so on. Every time a projecting fiber comes in contact with a pulley in drives of this usual kind it is reversed in direction. This occurs revolution after revolution, day after day, year after year, and there is, therefore little wonder that unless a belt is properly cared for it will wear out quickly.

It is evident that if the belt is "bone dry" the wear is bound to be more rapid than if it is lubricated, for the same reason that metallic rubbing surfaces must be lubricated if wear is to be reduced to the minimum. Lubricant fills up the rough spots in the metal, thus allowing the bumps to pass over one another.

In the case of a lubricated belt the action may be somewhat different. The lubricant will probably not fill up the entire space sufficiently to prevent the projecting fibers from coming in contact with the pulleys, but the fibers will be so well lubricated that they will bend back and forth more easily and without appreciable or serious wear.

No doubt there are several solutions to this problem. For mechanical reasons it is often undesirable to give such a twist to a belt as mentioned by Mr. Hyler. Perhaps it can be avoided by applying a wearing face to the belt and operating in the usual way. The writer, however, does not know of any practical wearing face aside from sticky preparations, and they often do more harm than good along the line of excessive power consumption. It may be, also, that the reversal of direction of projecting fibers has much to do with the pulling power of a belt. In the opinion of the writer greater pulling power can be obtained with a belt in which the fibers do not reverse, because contact can be made more intimate. That, however, must be left to experiments and experience, on which reports may be made later. Perhaps other readers of Power Plant Engineering have had experiences with "turned over" belts.

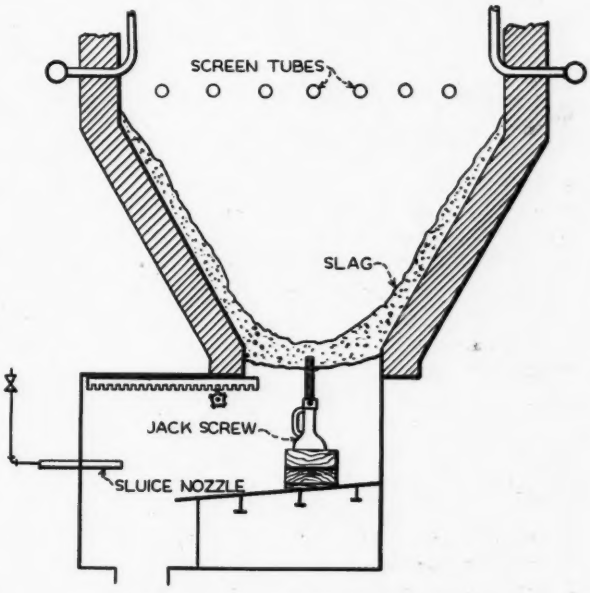
Newark, N. J. W. F. SCHAPHORST.

Jack Screw Effects Opening in Slag Deposit

DURING the operation at high ratings of pulverized fuel fired furnaces of the dry bottom type, care must be taken to avoid excessive temperatures in the region below the ash pit water screen. An abnormal concentration of heat in this portion of the furnace tends to fuse the accumulated refuse, and often causes serious slagging difficulties.

Perhaps the most troublesome of these difficulties results from the solidification of molten ash over the relatively cool refuse disposal openings. While this condition can be avoided by careful attention to furnace conditions, and the frequent dumping of refuse, it occasionally happens that these openings are completely blocked by an extremely hard mass of solid material.

Effecting an opening through this layer of solidified slag presents quite a problem. Where the deposit is not too thick, it is often possible to cut an opening



Jack screw as used to force hole in slag

with a bar, a hammer, and considerable muscular exertion. A stream of cold water played on the hot mass, while using the bar, will assist in breaking up the accumulation. After once breaking through the layer it is comparatively easy to enlarge the opening and effect complete removal.

Forcing an opening through a thick deposit with a bar and hammer is an almost interminable job. In a large industrial power plant such a deposit was recently experienced. After repeated efforts to break through the solid mass with the usual tools proved unsuccessful, a jack screw was pressed into service. By using the jack screw to force a piece of steel shafting through the mass of slag, an opening was easily effected, and it was possible to remove the accumulation before outage of the boiler unit became necessary.

Waynesboro, Va. S. H. COLEMAN.

(Another method which has been suggested for removing slag employs the use of a welding or cutting

torch. A description of results obtained by this method is needed before it can be recommended although it does seem to have some advantages over the common methods.—Editor)

Welded Drip Pocket

THIS HOME-MADE drip pocket and oil separator, shown in the accompanying sketches was made when piping up some pumps and it was found that the exhaust header was sufficiently below the existing installation to make it desirable to provide a drip pocket at the point shown.

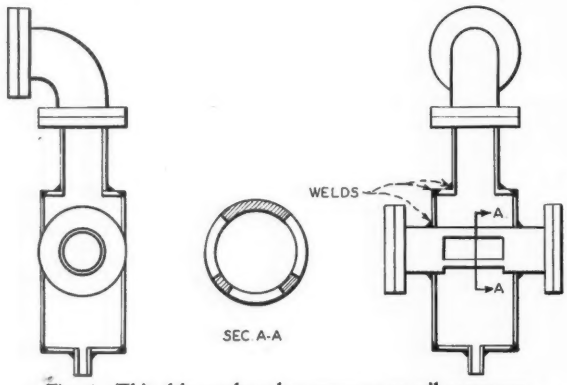


Fig. 1. This drip pocket also serves as an oil separator

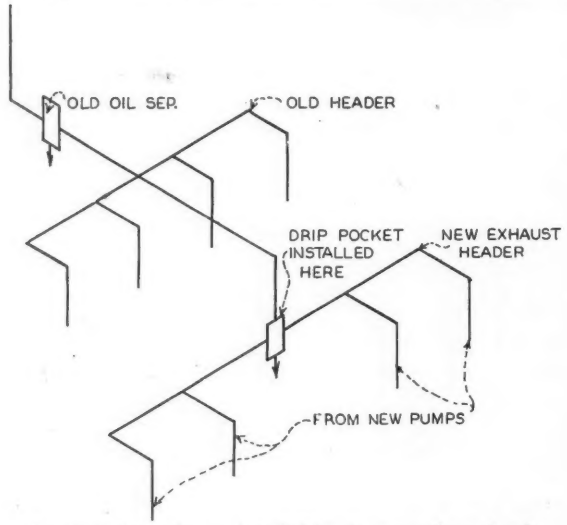


Fig. 2. Drip pocket as installed in the new exhaust header

Standard fittings would have made a bulky job and one very inconvenient to install, so it was decided to make up a welded job. The body, shown in Fig. 1, is made from a piece of 8-in. pipe, the inlets and outlet being 4-in.; the top and bottom are of ½-in. plate turned to fit the inside of the 8-in. pipe, the drip connection is a 1-in. coupling. The flanges were screwed on the inlets and outlet and the drip pocket placed in the line, and tack-welded and then removed to finish the welding job.

It was not intended that this should serve as an oil separator when it was installed as the outlet connects to another separator before the exhaust is used, but its use has shown that it has performed very well as such.

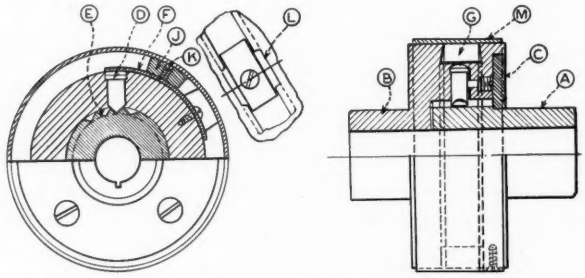
Clyde, N. Y. JULIUS BRODSKY.

Variable Slip Design of Flexible Coupling

IT IS OF a decided advantage on costly mechanisms to have a coupling between the power source and the mechanism so constructed that should any overload occur it will be possible for the coupling to slip before damaging the mechanism. If, further, such a coupling can be designed to be adjusted for any load from zero to maximum, then an additional advantage is obtained in that fewer couplings must be carried in stock for a given number of machines.

All the above factors were taken into consideration in the design of the coupling here illustrated.

This coupling is made in two main parts, one revolving inside of the other as shown at A and B and held in place by plate (C). Pin (D) rides in notches (E) and is kept in place by spring (F) in groove (G).



A screw pin maintains pin (D) in alinement with the notches.

The variability of the slip arrangement can be obtained in three ways. First, by increasing or decreasing the angle of the notches and pin. Second, by increasing or decreasing the thickness of the spring (F). Third, finer adjustment than the two above mentioned can be obtained by adjusting the shoe (J) and then tightening the set screw (K). Slot (L) allows the insertion of shoe (J) into the groove. Cover (M) gives the coupling a smooth rotating surface so as to prevent accidents.

This coupling has been installed on various pieces of machinery including motor generators, wrapping machines, pulverizers, machine tools and concrete mixers.

New York, N. Y. JOHN A. HONEGGER.

If We Were Taxed for Sunlight

We taxpayers are inclined to consider ourselves heavily and unjustly taxed for the necessities of life, here is cause for comfort: The most important necessity of all—sunlight—cost nothing whatever.

Takes for example a typical room such as the room I am seated in while writing this, 11 by 12 ft., in which there are three 50 watt lamps. At 10c per kilowatt-hour the cost of lighting this room is 1½c per hour, which, to most of us, is considered a reasonable rate. The lighting of this room is less intense than sunlight. The sun does a "better job." Let us therefore assume that sunshine is actually *worth* 1½ per hour on an area 11 by 12 ft.

The sun is continuously shining on the earth—on a disk 8000 miles in diameter—and has been doing so for millions of years without a second's interruption. The so-called "total eclipses of the sun" are not total at all. The area of the earth cut off by the moon is practically nothing.

So, applying mathematics, we find that the sun is continually shining on 50,200,000 square miles of earth. This is equivalent to 10,580,000,000,000 rooms of the size here mentioned—11 by 12 ft. At 1½c per room per hour it is a matter of simple multiplication to find that if the sun could and would demand payment for sunlight, our daily bill would amount to this tidy sum: $3,810,000,000,000. In other words, nearly four million million. War reparations, national deficits, cost of war, and such, of all nations combined, are swallowed up many times in this gigantic sum.

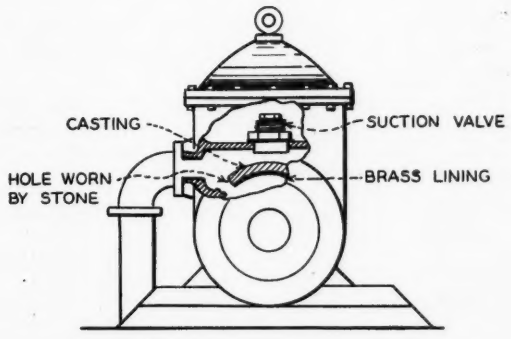
Shouldn't we be thankful that we are not taxed for sunlight?

Newark, N. J. W. F. SCHAPHORST.

Pump Destroyed by a Stone

THERE has just come to light a very peculiar incident relating to a vacuum pump used in connection with a heating system. This unit has been in operation, at the same location for over twenty years without distress except renewal of valves and packing.

A short time ago, what appeared to be a crack developed in the side of the water cylinder between the suction opening and the head end. Water squirted out in a fine jet and the vacuum was decidedly jerky, finally being broken. The pump went out of business and an immediate inspection was made. Not only was the outer casting leaking but the inner casting surrounding the cylinder bore and the brass lining also were in the same condition.



As a famous artist says, "Believe it or not," a stone the size of a hen's egg had been in that pump (between the outer and inner casting, forming the suction chamber) and constant rolling back and forth had finally worn a long groove in both outer and inner casting and the brass lining. Your guess is as good as mine but I wonder whether that stone was in the core and lodged in the corner while the pump was being machined. No water, from any source except the returns and a half inch jet line has ever entered this pump.

Lawrence, Mass. TOM THUMB.

Control Wire Identification

WHEN UNCOLORED CONTROL wires are used it is often necessary to identify them at condulets or junction boxes so that they may be tapped while others are not to be disturbed.

I have used two simple time-saving methods to identify these wires when wiring complicated control wiring. The advantages of these methods lies in the fact that no insulation need be disturbed.

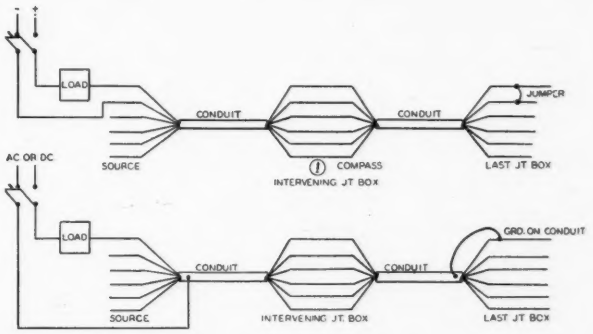


Figure 1 shows a method using direct current where an ordinary compass will indicate which is the positive or negative wire by using 10 to 20 amperes.

Figure 2 shows a method whereby either alternating or direct current can be used to warm up one wire at a time for identification when circulating a current which is sufficient for the size of wire used.

Iron Mountain, Mich. L. W. WYSS.

What Causes Sticking of Contactors?

IN THE large laundry served by our power plant, the washers are reversed by a number of finger contacts controlling the motors. The main control panel has three magnetic contactors, one for forward motion, one for reverse and the third for the main circuit controlling full speed of the motor it is associated with.

One of these three contactors has been giving me trouble in that it sticks closed. It stays "in" when the current is off until the adjacent contactor with its interlocking arm knocks it out. This causes the washers to reverse almost instantly, resulting in excessive shock and often broken gears.

I have cleaned the contactor faces, filed them off and made certain that no mechanical action is making it stay "in." It does not stick closed all the time. In several instances, after it stuck but before it was opened by the interlocking device, I pulled the main switch but the contactor remained in. When I replaced the contactor with a new one it operated normally for a while but after a time a sort of bitumatic compound appears which seems to cause the sticking. Where this compound comes from I cannot understand. It apparently does not issue from the coil but appears on the contactor faces.

Can anybody give me information as to what might cause this peculiar condition and how to remedy it? The coils are not defective. The motors used are 3 hp. 3 phase, 220 v. C. V.

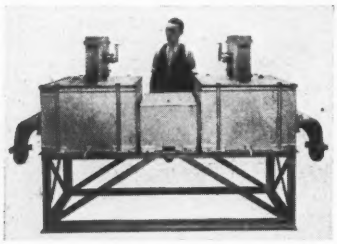
New Equipment

Oil Immersed 15 kv. Disconnect Switch

WITH THE INCREASING demand for continuity of power in industries, maintenance engineers are finding it difficult to get electrical equipment out of service to do manual maintenance work.

Under these conditions the necessity of more than one source of feed is essential and to provide facilities to handle additional sources at a reasonable cost, a new oil immersed disconnect has been developed.

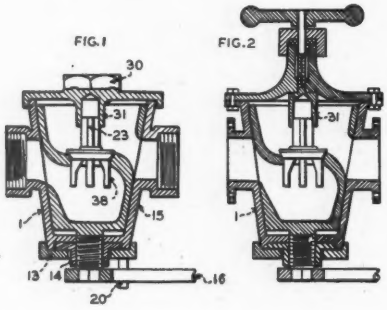
The design provides necessary safety features, great flexibility in application,



rugged construction and easy maintenance. Being watertight it can be installed in wet manholes, needs no protection and is well adapted for use in steel mills, flour mills and industries where dirt, dust and explosive hazards are factors. It is manufactured by Delta-Star Electric Co., Chicago, Ill.

Plug Stop Valve with Reversible-Flow Check

IN THIS VALVE, developed by H. L. Raulerson, 1826 N.W. 35th St., Miami, Florida, are combined features which adapt it to a multitude of services. As seen in Fig. 1, flow is from left to right, through check valve 23, which is carried in the plug 38. The lift of the check is limited by stop 31. Bonnet 30 covers the end of the plug and body, while the plug position is adjusted by regulating nut 14, which bears on partition 15 to draw the plug into the body or on riding cover 13 to loosen the plug from its seat. In the position shown, the check prevents flow from right to left; if the plug be turned 180 deg. by means of the handle 16, check action will be in the reverse direction



and prevent flow from left to right. When the plug is turned 90 deg., from the position shown, the stop valve is closed, all flow is prevented and all pressure is shut off the check valve. As the plug is held to its seat by nut 14, bonnet 30 may be removed and the check valve seat reground, which can easily be done, as the large end of the plug gives ample space to work. Stop 20 limits the motion of the handle 16 and ensures that the check valve will always work in the same direction unless intentionally reversed.

Advantages of a combined stop and check valve, in which the check may be repaired, are obvious; also the uses of a reversible check for backwashing filters, bilge lines and the like.

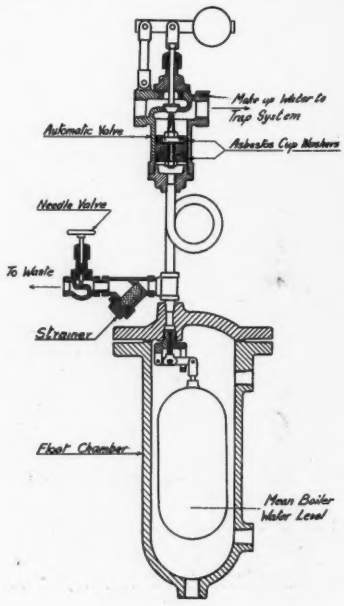
Figure 2 shows the valve with bolted flanges and bonnet for large sizes and higher pressures; also a design for limiting the lift of the check valve to regulate the flow through the valve, stop 31 being adjustable by means of the screw stem and hand wheel. This feature is of use for lines feeding boilers from a common header or wherever it is desired to vary the flow through the valve from time to time.

In smaller sizes, the valve is of solid bronze; in larger sizes, it has iron or steel body and bonnets with bronze bushings and trim.

Morehead Automatic Control

MOREHEAD MANUFACTURING Co., Detroit, Mich., announces the completion of an automatic control for make-up water for use with Morehead Back-To-Boiler systems. The apparatus automatically provides make-up water as the boiler demands. It is simple in design and is easily installed in connection with any back-to-boiler system.

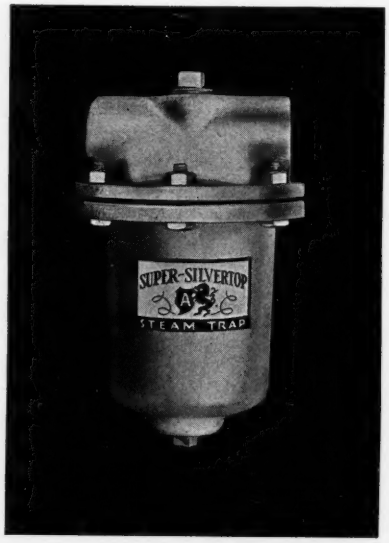
When the level of the water in the boiler falls, steam pressure is released



from the float chamber to the line connecting the under side of the piston in the automatic valve, thus raising the piston which pushes the weighted valve off its seat, allowing the make-up water to flow to the trap when in a receiving position. As water rises in the boiler, the float (in float chamber) eventually shuts off the pressure supply to the automatic valve. The steam pressure remaining in the line bleeds out through the screen and needle valve and the weighted valve returns to its seat, cutting off the flow of water until the fall of water level in the boiler again releases steam for another operating cycle.

Air Eliminator for Anderson Trap

FOR REMOVING entrained air from cold steam systems a new air eliminator has been developed for Anderson Super Silvertop Inverted Bucket Steam Traps by The V. D. Anderson Co. of Cleveland, Ohio. This device utilizes the Spencer thermostatic disc which takes the place of the usual thermal strip in blast traps. In the cold position, the disc curves out and away from three large auxiliary ports on the side of the inverted bucket. Air can then pass rapidly through the trap.

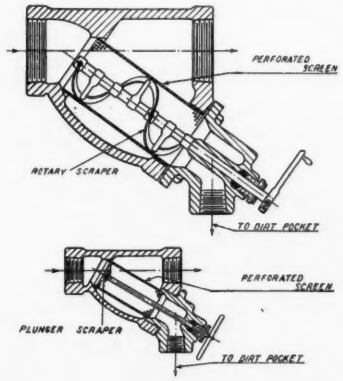


The eliminator remains wide open until the critical temperature (which accompanies live steam) is reached. It then snaps abruptly to the closed position, tightly covering the ports. The trap then operates normally.

The eliminator is always either wide open for discharging air or tightly shut. This insures that there will be no delay in air elimination due to premature closing, and no steam loss due to slow closing. This air eliminator is available only on Anderson Super Silvertop inverted bucket steam traps.

Sarco Strainer has Cleaning Device

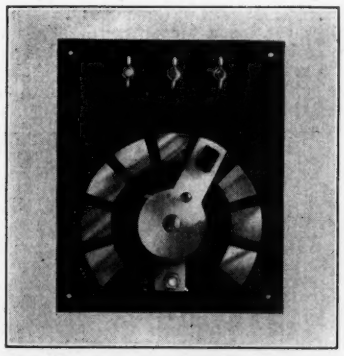
BY EQUIPPING its pipe line strainer with either a rotary or plunger scraper within the cylindrical screen, the Sarco



Co., Inc., 183 Madison Ave, New York City, has produced a design that may be easily cleaned at any time without removing it from the pipe line. This type strainer is particularly suited for use on oil lines and other services where the flow is continuous, and for this service it may take the place of duplex strainers.

Dial Switch Control

ELECTRIC WELDING has been simplified by an improvement announced by Miller Electric Mfg. Co., Inc., Appleton, Wisconsin, applicable to "Miller's Wonder Arc Welder." It is a dial switch control by means of which the electric welder can be operated without directions.

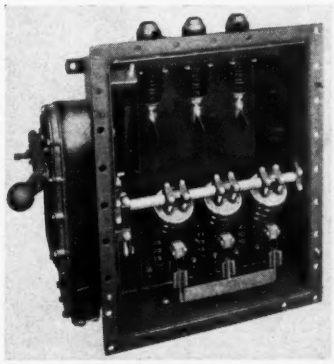


As illustrated here, the dial switch control has the amperage distinctly marked on the switchboard, indicating each step in welding. Setting the dial at the proper figures gives the operator absolute control of the amperage. Its use also makes the welder easier to operate, stabilizes the arc and prevents sticking.

The dial switch control is so designed as to prevent a "short" in the electrical circuit between contacts. The operator must place the switch dial in the correct position before the welder can be operated, making this an added safety feature.

New Oil Immersed Switch

THE DELTA-STAR ELECTRIC CO., Chicago, Illinois, has developed a new 3-position oil immersed 7.5-kv. switch unit for mounting directly on, or in proximity to, a transformer. It is designed for sectionalizing from the line and can be used in either net-work or radial systems. A locked-off position is provided



for sectionalizing purposes and cable grounding when men are working.

The switch may be locked in all three positions by a mechanical interlock, and provision is also made for a padlock preventing unauthorized operation. The electrical interlock prevents switch operation if line and transformer are alive.

Pipe Insulation

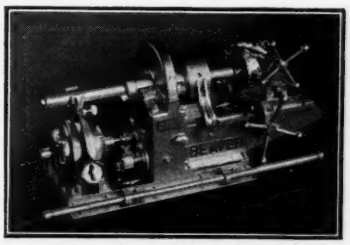
JOHNS-MANVILLE, New York, N. Y., announce a new type of insulation for cold lines known as Rock Cork Pipe Covering, which is the same basic material as Rock Cork Sheets used for years to insulate cold storage rooms and refrigerated equipment.

Like the sheet form, the new covering is made of specially waterproofed rock wool, thus being mineral in composition and inherently permanent in character. The most important feature of the material is the factory-applied waterproof jacket which provides, in addition to the unusual moisture resistance of the material itself, an absolutely waterproof hermetic seal against the infiltration of moisture-laden air.

Fittings are insulated with multiple layers of Zerotex, a waterproofed rock wool designed for the purpose. Each layer of Zerotex is sealed with a double-wrapping of a special waterproofed sealing tape, and the insulation of the fitting is completed with a layer of an asphalt base plastic.

Beaver Pipe Machine

MODEL A Special pipe machine is a new product of Beaver Pipe Tools, Inc., Warren, Ohio, which will cut, thread, ream and chamfer all sizes of pipe from ⅛ to 2 in.; it will operate geared tools to cut and thread 2½ to 12-in. pipe; it

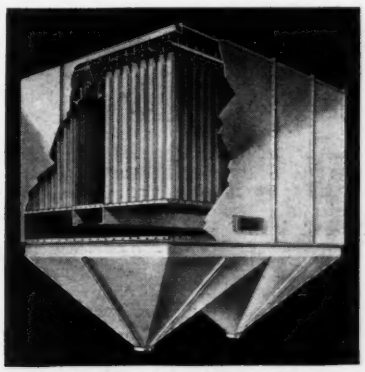


will cut off solid round bars or stayrods ¼ to 1 in. in diameter and thread bolts and stayrods from ¼ to 2 in.

Some other features of this machine are that the feed is manual by a large star wheel, it leaves very little burr in the operation of cutting off pipe but what remains is immediately removed by a swinging cone type reamer, the wheels and rollers are standard, and the machine will cut steel, wrought iron, brass, copper or cast-iron pipe.

Dustube Collector

AMERICAN DUSTUBE COLLECTOR is announced by The American Foundry Equipment Co., 555 Byrkit St., Mishawaka, Ind. The heart of the collector is the long tube made of special woven fabric which can be changed to suit the specific installation. The tubes are hung from racks in the ceiling. Self-acting dust seals hold the tubes to the bottom, without clamps or bands. Spring suspension of the dust tubes maintain the proper tension on the cloth making it easier to insert or take out dust tubes when desired.



Conveyor Scale

FAIRBANKS, MORSE & Co. announce a conveyor feeder scale for weighing and continuously integrating conveyor loads in transit on a belt conveyor. The machine is a complete, self-contained unit and is available in lengths from 8 to 30 ft. for any width desired. For the usual belt conveyor a suitable frame and means for suspending a section of the belt and integrating mechanism is furnished with the unit. This integrating mechanism consists of a cone and rotating switch driven by a flexible shaft; an integrating wheel mounted on a hollow shaft and driven by the cone; and a reversible motor with a pinion gear which engages a rack which raises or lowers the integrating wheel on the face of the cone.

Pipe Line Insulation

KNOWN AS ADSCO CELL-CONCRETE, for underground steam and hot water pipe lines, possessing low heat conductivity, and the ability to retain its physical strength and shape as well as completely regain its insulating value after repeated submergence in water, a new insulation is being offered by the American District Steam Co., North Tonawanda, N. Y. It is made entirely from Portland cement mixed with a foam, producing a light weight cellular concrete of a specific gravity of approximately 0.3. It can be mixed on the job and poured around one or more pipes in conduits of various constructions at low cost, resulting in a rigid, permanent installation.

Elastic Asphalt

AN ELASTIC ASPHALT compound in liquid form, made from Mexican asphalt, has been made available by the Elastic Asphalt Co., Chicago, Ill., for application under the base of high speed machines of moderate size and weight to absorb vibration. The material is poured, just as it comes from the containers without heating, into space in the foundation made the exact size of machine base, then troweled to a smooth surface much as would be done with concrete. It adheres tightly to concrete, wood or metal and will not extrude or flow below temperatures of 200 deg. F.

In behavior, after setting, it resembles sponge rubber, having a larger percentage of air cells distributed through it and developing a considerable elasticity and resiliency. The setting or drying time is 6 to 24 hr., depending upon atmosphere conditions of heat and moisture.

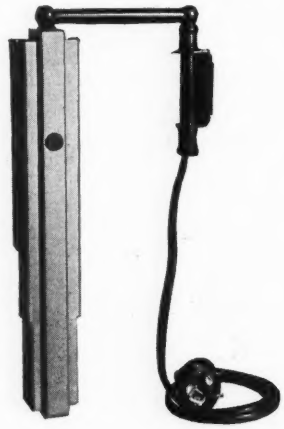
In general elastic asphalt has the ordinary properties of common asphalts in being waterproof, not affected by acids or alkalies.

Experiments with this material in a modified form, as a resilient coating on certain types of fabric conveyor belts have proved satisfactory. Cotton fabric or stitched canvas belts are coated by troweling on and the coating can be renewed in many cases, without removing the belt from the pulleys.

Elastic asphalt was first used some years ago, and the greatest field still is, as an expansion joint seal both used alone and in connection with different types of metal expansion joints for highways, sidewalks, pools, roofs and all structures necessitating waterproof expansion joints.

Condensation Control

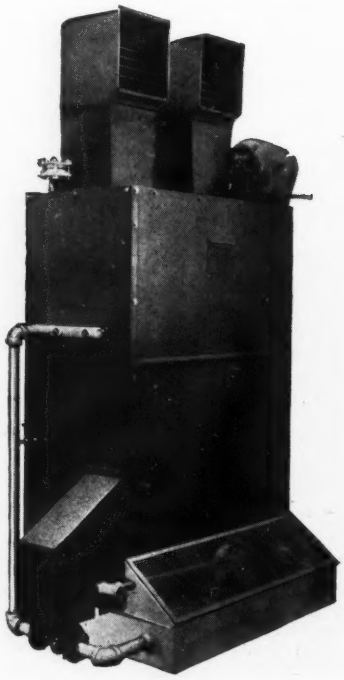
FOR CONTROLLING condensation on windows, walls and other cold surfaces, a new instrument, the Windowstat, is announced by Julien P. Friez & Sons, Inc., Baltimore, Md. The Windowstat is located at



the point where condensation is to be expected and controls the air conditioner or humidifier so as to maintain the room humidity above the point where condensation will take place.

York Economizer

YORK ICE MACH. CORP., York, Pa., announce a new piece of apparatus: an economizer which is designed to reduce water consumption of air conditioning systems. It is a combination forced draft cooling tower and refrigerant condenser, arranged either for indoor or outdoor installation—being used indoors by providing ducts to bring in outside air and exhaust the heated, humidified air to the atmosphere.



A fan passes the outside air through a bank of bare pipe coils over which water trickles in a direction opposite to the air flow, to give a Baudelot cooling action. Refrigerant is condensed inside the coils, and flows by gravity to the liquid receiver built in the base.

New Electrode

AERISWELD, a new phosphor bronze arc welding electrode has just been announced by The Lincoln Electric Co., Cleveland, Ohio, after thorough tests in the practical welding of bronze, brass and copper in many applications. The electrode provides a solid homogeneous deposit, having characteristics of true phosphor bronze with notably high tensile strength.

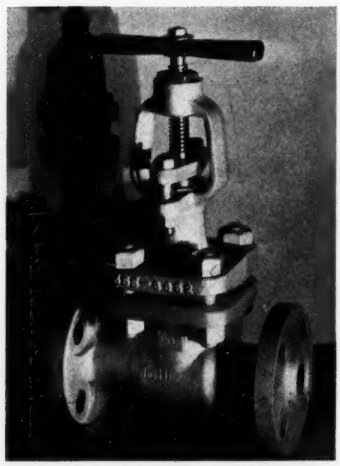
Some of the many applications for "Aerisweld" include: Busbars, large contacts, impeller blades in pumps and turbines, ornamental bronze, bronze doors, etc. Many types of bronzes which are exceedingly difficult to braze, are readily welded. The electrode is also valuable for welding galvanized sheets where minimum disturbance of the galvanizing is essential.

In reclamation of worn parts of equipment, 'Aerisweld" is used to build up and fill in bronze castings such as journal boxes and containers, for building up bronze valve seats, bronze bearing surfaces on steel or cast iron, and numerous guides.

"Aerisweld" is a shielded arc electrode, for use with the metallic arc. Its coating, as it burns, produces a gas which shields the molten metal from harmful effects of the atmosphere and assists in easing the flow of molten metal in the arc.

Hancock Steel Valves

FORGED STEEL globe valves embodying new features of design have recently been announced by the Hancock Valve Division of Consolidated Ashcroft-Hancock Co., Inc., Bridgeport, Connecticut. These valves are made for pressure ratings up to 1500 lb. and are specially designed with a tongue-and-groove bolted bonnet for high temperature service. They are



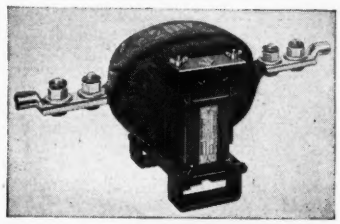
made in either cone or plug type and the valve seat ring and disc are made of exceptionally hard, heat-treated stainless

steel that resists wire drawing, indenting, and galling.

All parts are made of steel for safety against fire hazards; long condensation chamber protects and increases life of packing; all wearing parts are renewable; and the seat ring is easily removed with a standard hex wrench.

Secondary Terminal Block

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., now equips its current transformers for metering services with a new molded secondary terminal block having many desirable features. All conducting parts are embedded in molded phenolic insulation to obtain maximum reliability. The short-circuiting strap is manually operated. Spring contacts and automatic devices are eliminated in order to insure correct operation and accurate meter readings. The



cover may be removed without disturbing electrical connections and it cannot be seated in position while the secondary is short-circuited. Separate terminals are provided for meter connections, thus eliminating the danger of loosening the connections to the winding. Terminals are of ample size to accommodate the largest secondary meter cable that is normally used. The location of the block, its snug fitting cable openings, and its sealable wing nuts on the cover, all combine to discourage tampering.

Elwood Mead

DR. ELWOOD MEAD, Commissioner of Reclamation since 1924, died at his home in Washington, D. C., on January 26, 1936, after an illness of several weeks. Dr. Mead was born January 16, 1858, at Patriot, Ind., and graduated from Purdue University with a degree of Bachelor of Science in 1882; received a Civil Engineering a degree from Iowa State College of Agriculture in 1883 and a degree of Master of Science in 1884 from Purdue. In 1904 he received from Purdue an honorary degree of Doctor of Engineering, the first given by that university, and in 1925 the honorary degree of Doctor of Laws from the University of Michigan.

He began his career as an assistant engineer of the army on a survey of the Wabash River and in 1886, after two years as professor of Mathematics, he became professor of Irrigation Engineering at the Colorado Agricultural College, the first such chair held in an American school. He served Colorado as assistant state engineer and later went to Wyoming as territorial engineer, becoming first state engineer from 1888 to 1889.

When the new state was being organized, Dr. Mead proposed an entirely new water law under which the state retained title to all water, surface and underground. Water was given a status similar to minerals and the change has had far-reaching effect on the legal status of irrigation. He served as chief of the irrigation and drainage section of the Department of Agriculture for 8 yr. ending in 1907 and served the University of California concurrently as professor of Institutions and Practice of Irrigation.

In 1907 he went to Australia where he inaugurated a comprehensive water conservation and reclamation plan in Victoria. Returned to the United States in 1915 he resumed his teaching at the University of California until 1924 when President Coolidge appointed him Reclamation Commissioner. Other foreign experience include: The Holy Land, Cuba, Haiti, New South Wales, Canada, Hawaii, Java and Mexico.

Dr. Mead was a member and past director of the American Society of Civil Engineers, a member and past president of the American Society of Engineers, a member of the American Society of Agricultural Engineers, and the British Institute of Civil Engineers. He was a member of the water resources committee of the National Resources Committee and served on numerous government commissions and committees.

WALTER S. TOWER, Executive Secretary of American Iron and Steel Institute, stated in an address before the California State Chamber of Commerce at Del Monte, Cal., that the steel industry will spend approximately $200,000,000 for modernizing equipment and for new finishing capacity in 1936. "The expected outlay this year compares with $140,000,000 in 1935," said Mr. Tower. "These expenditures will add little or nothing to the capacity of the industry to produce raw steel. Practically every dollar is being spent to improve methods of manufacture and to make a better product for the customer."

Midwest Power Engineering Conference

MANY DEVELOPMENTS in the field of power have taken place since the last Midwest Power Conference was held and the program now being arranged for the meeting in Chicago, April 20 to 24, will have many sessions dealing not only with broad principles but with specific problems of equipment and materials. Frank D. Chase, President of the Conference, believes that the public as well as power engineers need to have brought forcefully to their attention the great progress the industry has made and what is now being done for the general welfare.

With such a theme in mind, the program is planned with sessions on power economics, power plant buildings and dams, Diesel power, refrigeration, fuels, power piping and welding, engineering economics in the national power picture, power plant technique, power transmission to machinery, fuel economy and controls. The authors and speakers, some thirty-five in number, that have been secured for these sessions are of national and international reputation in their respective fields and unquestionably many new practices in the power field will be discussed. Morning sessions will be held in the Palmer House while the afternoon sessions will be held at the Ampitheater.

During the week of the Power Engineering Conference an additional attraction is the Midwest Engineering and Power Exposition which will be held at the International Amphitheater and through exhibits of several universities as well as those of a number of manufacturers will emphasize the educational phase of the power industry.

News From the Field

THE JOHNSTON & JENNINGS CO., Cleveland, Ohio, announces the appointment of the Faville-LeVally Corp., 140 S. Dearborn St., Chicago, as sales and engineering representatives of the company's stokers in the Chicago territory. W. J. Williams, for many years with The Edgemore Boiler Co., is now connected with the Faville-LeVally Corp.

MODINE MANUFACTURING CO., Racine, Wis., announces the appointment of Charles J. Gaskell as its representative in Memphis, Tenn. Mr. Gaskell will cover the western part of Tennessee, the northern part of Mississippi and the eastern part of Arkansas. His office is located in the Falls Building in Memphis.

JOHNS-MANVILLE SALES CORP., has announced the appointment of George Dandrow as Manager of the New York District of the Power Products and Industrial Department, with offices at 22 East 40th St., New York City. Mr. Dandrow joined the Johns-Manville organization in 1922 directly following his graduation from the Massachusetts Institute of Technology. After 5 yr. in Johns-Manville's Boston branch, he joined the general engineering staff at Headquarters in New York and for the last few years has been Assistant Manager of the New York District.

ANNOUNCEMENT is made by Foster Wheeler Corp. that James Cleary has been appointed as special representative in the Power Equipment Division. Mr. Cleary's headquarters are at the New York office of the corporation, 165 Broadway.

ANNOUNCEMENT has been made that James E. De Long, executive vice president of Waukesha Motor Co. was appointed general manager, effective January 7. He will also continue as head of the executive board, established in 1928. Mr. De Long has been connected with the Waukesha Motor Company for 13 yrs., having joined the organization in 1923 as field engineer in charge of oil industry operations.

CENTRIFIX CORP., Cleveland, Ohio, announces the appointment of George W. Stetson, 141 Milk St., Boston, Mass., as sales representative in the New England states for Centrifix purifiers.

LINK-BELT CO. has moved its district sales office in St. Louis, Mo., from 3638 Olive St. to 1018-21 Louderman Building, 317 N. 11th St. Larger quarters are thus provided in the heart of the St. Louis business district. Howard L. Purdon is district sales manager.

HENDRIE & BOLTHOFF Mfg. & Supply Co., Denver, Colo., has been appointed representative for Hagan Corp., Hall Laboratories and The Buromin Co. in that territory.

THE UNIVERSITY OF WISCONSIN has announced the Second Conference on Solid Fuels and Domestic Stokers to be held in the Mechanical Engineering Bldg., the College of Engineering, University of Wisconsin, Madison, Wis., on April 21, 22 and 23. The program will consist of lectures, demonstrations, exhibits and many other interesting and valuable features. Professor L. A. Wilson, Mechanical Engineering Bldg., is prepared to answer inquiries concerning the Conference.

FRANK C. BALKE, who for many years had been chief engineer at the Hollenden Hotel in Cleveland, Ohio, died at the age of 52 years on February 6 following a long illness. Mr. Balke had been an employee of the Hollenden for some 30 yr., having received his education at the West Technical High School, later being employed by the Cleveland Chamber of Commerce from which position he went with the Hollenden Hotel in 1905, working his way from an engine room employee to chief engineer and superintendent of the building.

DANIEL W. MEAD, consulting engineer on hydraulic work and power plants, and Professor Emeritus of Hydraulic and Sanitary Engineering, University of Wisconsin, was elected president of the American Society of Civil Engineers at its annual meeting in New York, January 15-17.

THE JOHNS HOPKINS UNIVERSITY, School of Engineering, has arranged a course of lectures on engineering practice which will discuss the daily working methods of design, construction and operation and the special properties of materials involved. The course will comprise 7 lectures by members of the staff of mechanical engineering on the properties of important metals and alloys as used in the technical industry. They will develop the fundamental theory of alloys and the application of this theory to the preparation, selection and use of metals for industrial purposes with particular reference to recent developments. These lectures will be open to the public and are intended for engineers, plant managers, foremen and mechanics. They will be given on Wednesday evenings at 8 o'clock, the first lecture being on March 4. Others at weekly intervals up to and including April 22.

YARNALL-WARING CO., Philadelphia, announces the appointment of the following representatives: H. F. Heineman, Wabash Building, Pittsburgh, will handle the sale of Yarway products in western Pennsylvania and West Virginia. Edgar D. Harder, 2424 National Bank Building, Detroit, will assist in the sale of Yarway lines in the Ohio-Michigan district.

DIESELS have been adopted as standard equipment on the entire line of excavators made by the Harnischfeger Corp., Milwaukee, Wis. This announcement comes simultaneously with that of the new P & H Pacemakers, a completely redesigned line of excavators utilizing new high tensile alloy steel and arc welded construction.

CONTRACTS for 15 large pumps have been awarded by the Metropolitan Water District of Los Angeles, Calif., for use in the aqueduct running between that city and the Colorado River. Six of these pumps, each with a capacity of 90,000 g.p.m. against a total head of 460 ft., and requiring 1200 hp. each, were awarded to the Worthington Pump & Machinery Corp. Six 8000-hp. units were awarded to the Byron Jackson Co., Berkeley, Calif., and three 5000-hp. units to the Allis-Chalmers Mfg. Co., Milwaukee, Wis.

FOR FOUR DAYS, from March 31 to April 3, the Fourth Annual Short Course on warm air heating and cooling will be held at Michigan State College, Lansing, Mich., under the auspices of the National Warm Air Heating & Air Conditioning Association. The four day course will give all the theory necessary in making calculations for a complete air conditioning installation in an insulated home and will be thoroughly practical. The cost of the course is covered by the two dollar registration fee. Those interested should write to Professor L. G. Miller, Department of Mechanical Engineering, Michigan State College, East Lansing, Mich., and enclose the two dollar registration fee. The course is limited to a total of 300 students.

DIESEL ELECTRIC LOCOMOTIVES for four new Burlington Railroad streamlined trains will be built by the Electro-Motive Corp., LaGrange, Ill. In contrast to existing streamlined trains, the locomotives will be separate from the passenger cars. Two 3000-hp. locomotives will operate the new 16-hr. Chicago to Denver trains and the two 1800 hp. locomotives will replace the present Zephyrs between Chicago and Minneapolis. The Chicago-Denver trains will make approximately 65 miles an hour and cut the present 27 hr. and 45 min. schedule to 16 hrs. The Chicago-Denver trains will go into service in June and the Chicago-Minneapolis trains in July. The former will have 10 light-weight stainless steel passenger cars and the latter six.

DIESEL POWER represented by a 35-kw. Winton engine will form the power and lighting facilities of the General Motor's Parade of Progress during the coming summer. This "World's Fair on Wheels" will make a 20,000 mi. tour to demonstrate the wonders of modern science to cities and towns along the route. There will be 28 motor vehicles in the caravan and the lighting unit will provide voltages of 220 a.c., 110 a.c. and d.c. and frequencies as high as 1600 cycles in order to properly demonstrate such seeming magic as frying an egg on ice and other feats which proved so popular at the World's Fair in Chicago.

DAWSON HANCOCK SKEEN, head of D. H. Skeen & Co., Chicago, died February 23 at his home in Flossmoor after a short illness of pneumonia. Mr. Skeen was born in Bell Buckle, Tenn., graduated from the Annapolis Naval academy in the class of 1910; was manager of the electric power company at Fulton, Ky., when war broke out, and was recalled to the service. He joined the Edward Valve and Manufacturing company in East Chicago after the war and later established the engineering sales concern bearing his name. He was a member of the American Society of Mechanical Engineers and the Western Society of Engineers. Mr. Skeen is survived by his widow, Mrs. Elizabeth Bennett Skeen, and two children, Nancy and Drake H.

For the Engineer's Library

Mathematics of Modern Engineering. By Robert E. Doherty and Ernest G. Keller. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Size 6 by 9 in., 303 pages, price $3.50.

This is one of a series of books written for the advanced course in engineering given by the General Electric Co. and is a treatment of higher mathematics from the standpoint of actual mechanical and electrical engineering. The mathematical methods advocated are offered as an aid in solving practical problems and emphasis is placed upon the scientific approach.

In the author's opinion the use of mathematics as a tool in straight thinking is not what it should be, not, as is sometimes implied, because mathematics is poorly taught, but because engineering teachers do not make use of it after the basic concepts and forms are learned by the student. The book is divided into four chapters, each with several subdivisions and covers basic engineering mathematics and ordinary differential equations through vector analysis and Heaviside's operational calculus. The authors are, respectively, dean of engineering, Yale University, and associate professor of applied mathematics, University of Texas.

MERCOID AUTOMATIC CONTROLS used for heating, air conditioning, refrigeration and industrial applications are made the subject of the general abridged catalog number 100 recently issued by The Mercoid Corp., 4201 Belmont Ave., Chicago, Ill. The controls listed are in the form of thermostats, time switches, pressure and temperature controls, furnace and fan controls and numerous other devices to control physical conditions in industrial processes. Each device is illustrated and described and prices are listed.

ROTARY PUMPS; specifications, applications and uses, are covered by three specification sheets recently issued by the Worthington Pump & Machinery Corp., Harrison, N. J. They are W-475-B10, B11 and B12.

THE B. F. GOODRICH CO., Akron, Ohio, is distributing a 28 page cost finding record book for conveyor belts. Each conveyor record covers two pages, giving pertinent information, tonnage handled, maintenance cost, remarks and space for a sketch showing the installation. In the back of the book are four pages of conveyor belt data showing methods of prolonging the life of conveyor belts and the various types of conveyor belts made by the company.

JOHNS-MANVILLE, 22 E. 40th St., New York City, has issued a booklet entitled "Doctors of Packing" which is an absorbing history of the development of packings used in industry. The booklet points out that the entry into the field of high pressures and increased machine speeds has elevated the problem of packings to high importance and sketches the part played by scientists in improving packing to its present efficiency.

LEEDS & NORTHRUP CO., 4900 Stenton Ave., Philadelphia, Pa., has recently issued its bulletin No. 4001 entitled Efficient Regulation of an Air Conditioning System and describing the part played in this system by the three-lead, null-type electrical-resistance thermometers manufactured by the company.

THE EDWARD VALVE & MFG. CO., Inc., East Chicago, Ind., has issued its catalog No. 11-D, the subject of which is the Edward Blow-Off Valves. The bulletin is fully illustrated with halftones of cross sectional wash drawings and contains tables of materials used, dimensions and ratings.

THE SWARTWOUT CO., 18511 Euclid Ave., Cleveland, O., has recently issued two interesting bulletins, one dealing with the Swartwout desuperheater and governor, designated as Bulletin S-21-C, and the other, bulletin S-100E, is a list of important installations of Swartwout carburetor type desuperheaters together with related reducing and regulating equipment.

INGERSOLL-RAND CO., Phillipsburg, N. J., has published a new bulletin describing the company's line of power driven, horizontal duplex, double acting, cross head type, moderate speed, heavy duty compressors which are built in capacities ranging from 50 to 250 hp. for single and multi-stage compression. This bulletin is designated as No. 3162.

THERMAL EXPANSION Characteristics of Some Nickel Cast Irons is the subject of Section 3, No. 6 of Nickel Cast Iron Data published by The International Nickel Co., 67 Wall St., New York, N. Y. This bulletin includes data on recent research which indicates that alloy cast iron possesses a range of expansivity suitable for equipment subject to wide variations of temperature such as engine cylinders.

APPLICATION of steam jet refrigeration to the condensing and removal of objectional constituents of gas by cooling is described in a four-page folder of the Ingersoll-Rand Co., 11 Broadway, New York.

THE FAFNIR BEARING CO., New Britain, Conn., has just issued its Engineering Manual No. 35 which is a comprehensive review of the principles affecting the selection, application and operation of antifriction bearings and ball bearings in particular, prepared by the company in the form of a wire-bound book totaling almost 200 pages. It contains a complete and up-to-date resumé of the engineering fundamentals involved in correlating design requirements, load characteristics and service conditions to the choice of the particular size and type of bearing. The new manual is available without charge to executives and engineers responsible for bearing selection or maintenance. Such requests should be addressed, on company letterheads, to The Fafnir Bearing Co., New Britain, Conn.

THE FEDERAL POWER COMMISSION announces the publication of two important utility maps compiled by its National Power Survey, one showing the service areas and the other the chief generating plants and transmission lines of the principal electric utility systems in the United States. They are the first comprehensive maps of the kind based upon official reports of the utilities that have been published in this country. These are large wall maps, in full colors, one 51½ by 81 in. and the other 57½ by 84 in.; scale = 1:2,500,000; 1 in. equalling 40 mi. Each map covers approximately 90 percent of the industry.

These maps will be sold by the Federal Power Commission, Washington, D. C. The prices are: Map No. 1—Service Areas —Unmounted, in two sections, $7.50; Mounted on linen, with reinforcing rails, $10. Map No. 2—Plants and Transmission Lines—Unmounted, in two sections, $5.00; Mounted on linen, with reinforcing rails, $7.50.

THREE NEW BULLETINS have recently been issued by the Frick Company, Waynesboro, Pa. The first is a four-page announcement, 98-A, of two low pressure refrigerating units with overhead drive built at 15 and 20 t. capacities. The second is a four-page bulletin, 156-A, of the type VW cooling coils made in standard units with a surface of 53 and 82 sq. ft., and the third is a 12-page bulletin, 203-C, covering electric control valves for refrigerating plants.

THE ROTO CO., Newark, N. J., has issued a new tube cleaner manual and catalog which consists of two sections bound in a single cover—a "Tube Cleaner Manual," and a loose-leaf section describing the company's line. The manual illustrates with photographs and blue prints, various problems of mechanical tube cleaning and their solution. Besides tracing and illustrating the history of tube cleaners, the manual briefly covers the formation and prevention of principal types of scale, the losses due to scale, and the frequency of tube cleaning. The problem of cleaning curved tubes and the function of the various types of motors and heads are covered and illustrated in great detail.

AN INDEX to A.S.T.M. Standards and Tentative Standards, totaling some 794, is being furnished without charge on written request to the headquarters of the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

APPLICATION AND DATA regarding the use of heat exchangers with Diesel exhaust gas and jacket water are contained in an 8-page bulletin of the Sims Co., Erie, Pa. Typical piping diagrams, exchanger types and dimensions and requirements for different sized units, are included.

A smaller bulletin of the same company describes the application of small Sims heat exchangers to the application of accurate samples for boiler water and steam condensate analysis for water treatment purposes.

CABLE OPERATION, Publication C-11 of the Edison Electric Institute, 420 Lexington Ave., New York, N. Y., is the report of the Transmission and Distribution Committee. The price to non-members in the U. S. A. is $1.50. During the past 5 yr. the rate of failure of cable joints has decreased 51 per cent and cable failure 24 per cent. Detailed records of the member companies are included in the report.

VERTICAL, FOUR CYCLE, direct injection engines known as Type D are described in Bulletin S-500-B30 of the Worthington Pump & Machinery Corp., Harrison, N. J.

CONSTRUCTION, design and application of the enclosed type Freon compressors are covered in a 16-page bulletin, No. 508-A, of the Frick Co., Waynesboro, Pa.

FULL PARTICULARS of the new Building and Public Works Laboratories, opened in Paris last June, are included in a special 284 pp. November number of the L'Entreprise Francaise in an endeavor to show scientists, engineers and manufacturers the facilities which the laboratories place at their disposal for materials testing. The price of this special number is 50 francs (plus 9 francs postage in Great Britain and the U.S.A.) and copies may be obtained direct from the publishers 9 Avenue Victoria, Paris IV e, France.

THE DEBEVOISE CO., 968 Grand St., Brooklyn, N. Y., has issued a pamphlet entitled "Erosion—Its prevention and cure through the use of Debecote." The pamphlet is a report for engineers and others interested in economies in power production and the prevention of corrosion from water in motion, particularly as applied to condenser tubes.

PALMER-BEE CO., Detroit, Mich., has issued Section 111 of its General Catalog 100 dealing specifically with skip hoist and drag line machinery. The catalog describes many recent improvements in the design of the company's products which have made this equipment of greater strength, durability and effectiveness, accomplished through the use of modern alloy steel, heat treatments, rust and corrosion resisting processes.

NIAGARA SPRINKLER STOKERS are described in a new bulletin issued by the Niagara Combustion Corp., Niagara Falls, New York. These stokers are suitable for all types of solid fuels and are equipped with balanced forced draft, automatic control and may be used with high temperature preheated air.

THE NIAGARA COMBUSTION CORP., Niagara Falls, N. Y., has issued a pamphlet dealing with the Cumberland Electrolytic System for the prevention of corrosion and elimination of boiler scale. The bulletin describes the principles upon which the system operates, gives diagrams of connections and cites a number of installations.

DEFENDER AUTOMATIC REGULATOR CO., St. Louis, Mo., recently issued four new bulletins; No. 33A illustrating draft gages made in one, two or three pointer types in one aluminum case; No. 33-B, two and three pointer gages for draft and flue gas temperature or draft, wind box and flue gas temperature; No. 33-C, Junior Model gages with two pointers. No. DDA-3, Junior Model square form furnace draft regulator, consisting of a 1⅜ in. dia. water cylinder with 8 in. piston travel and with a pointer draft gage and wind box pressure gage mounted on front.

LATEST EQUIPMENT of Ruggles-Klingemann Mfg. Co., 38 Chauncy St., Boston, Mass., is shown in an 8 p. folder. This includes the new three-valve combination regulator, pump governors, solenoid balanced valves, special applications of hydraulic regulators and water level controllers.

GENERAL ELECTRIC CO. has issued two Bulletins, GET-622B (supersedes GET-622A) which is a chart for setting line drop compensators used with feeder voltage regulators, and GEA-1993A (supersedes GEA-1993) describing GE enclosed indicating and drop out fuse cutouts.

LOW HEAD axial flow pumps for large capacities are described in bulletin 226 issued by the Pennsylvania Pump & Compressor Co., Easton, Pa.

ELECTRICAL EQUIPMENT for measuring smoke density at the stack and which indicates and records wherever needed and signals major changes if desired, is described in a 16 page catalog, N-96, Micromax Smoke-Density Recorders, recently issued by Leeds & Northrup Co., Philadelphia, Pa.

Power Plant Construction News

Alaska, Seward — Municipal Council has plans maturing for proposed new municipal hydroelectric power plant in vicinity of Upper and Lower Lost Lakes, to be used as source of water supply. Initial installation will include two 375-kv-a. water turbine-generators and accessories. A transmission line, 11 miles long, will be built to municipality, where power substation will be located. Financing will be arranged soon. Hubbell & Waller Engineering Corporation, Alaska Building, Seattle, Wash., is consulting engineer.

Calif., Los Angeles — Metropolitan Water District, 306 West Third Street, will receive bids March 13 for Eagle Mountain pumping plant of Colorado River Aqueduct, to be located near Desert Centre, San Bernardino County, including inlet works, outlet structures, switching station, control house, generator and compressor station and other structures. F. E. Weymouth is general manager and chief engineer (Specifications No. 143).

Conn., Bristol — E. Ingraham Co., North Main Street, plans installation of electric power equipment in new three-story addition to clock manufacturing plant. Superstructure will soon be placed under way. Entire project will cost close to $50,000.

D. C., Washington—Bureau of Yards and Docks, Navy Department, will receive bids until March 25 for electrical equipment for power substation at navy yard, Pearl Harbor, T. H., including remodeling of present station (Specifications 8051).

Fla., Plant City—Carey Citrus Products Corporation plans installation of power equipment in connection with proposed rebuilding of packing and canning plant, recently destroyed by fire. Entire loss estimated over $80,000. G. A. Carey is head.

Ga., Atlanta—Chevrolet Motor Co., McDonough Road, plans installation of electric power equipment in new one-story addition to local assembly plant. Entire project will cost close to $250,000. Company headquarters are at 3044 West Grand Boulevard, Detroit, Mich.

Ill., Jacksonville—City Council has been authorized at special election to arrange bond issue for $230,000 for proposed municipal electric light and power plant, estimated to cost about $420,000, remainder of fund to be secured through Federal grant. Proposed to proceed with project at early date.

Ind., Indianapolis — Chevrolet Body Corporation, 1100 West Henry Street, plans installation of electric power equipment in new addition to automobile body-manufacturing works. Entire project will cost about $300,000. A building permit has been issued. Company is affiliated with the Chevrolet Motor Co., Detroit, Mich., both being subsidiaries of General Motors Corporation, General Motors Building, Detroit.

Iowa, Rock Rapids—Common Council is arranging early special election to approve bond issue of $200,000 for new municipal electric light and power plant. Proposed to begin work soon. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

La., New Orleans — Sewerage and Water Board, 526 Carondelet Street, will receive bids until April 2 for equipment for new sewage station and system, including electric-operated pumping machinery, motors, transformers, switchboards, instruments, etc., underground power cable and other equipment. This is part of a $2,770,000 improvement program, and is estimated to cost about $800,000 of total sum noted. Alfred Theard is general superintendent.

Mich., Alma — Northern Refineries, Inc., Alma, care of Joseph H. Fitchett, Alma, president, recently organized with capital of $150,000, plans installation of power equipment in new local oil refinery. Proposed to begin work in the spring. Financing is being arranged. Entire project will cost close to $100,000. E. G. Guy, Mount Pleasant, Mich., is consulting engineer.

Mich., Wakefield — Board of City Commissioners is considering plans for new municipal electric light and power plant. It is estimated to cost about $60,000. Financing will be carried out through Federal aid.

Minn., Bemidji — City Council has plans maturing for new municipal electric light and power plant, with steam division for central steam distribution for heating service. Proposed to arrange fund of $620,000 and special election has been called for such purpose. Burlingame & Hitchcock, Sexton Building, Minneapolis, Minn., are consulting engineers.

Mo., Jefferson City—State Bi-Partisan Advisory Board, Capitol Building, Edgar M. Egan, secretary, will have plans prepared at once for new power plant for State Penitentiary on local site. Proposed to ask bids soon. Cost close to $400,000. Charles A. Haskins, Finance Building, Kansas City, Mo., is supervising engineer; W. D. Weidlein & Co., Fairfax Building, Kansas City, Mo., are consulting engineers.

N. C., Charlotte—Johnston Mfg. Co., plans installation of electric power equipment in new one-story addition to cotton mill. Entire project will cost about $65,000. C. W. Johnston is president.

N. C., Shelby—City Council is considering construction of a new municipal electric light and power plant, estimated to cost about $225,000. Proposed to arrange financing through Federal aid. Plans will be drawn in near future.

N. D., Grand Forks—Grand Forks Terminal Elevator Co., care of Thomas Berge, 729 Reeves Street, Grand Forks, president, recently organized, plans installation of power equipment, hoisting machinery, conveyors and other mechanical equipment in new grain elevator plant. Entire project will cost about $125,000. Financing is being arranged.

Ohio, Cleveland — Dobeckmun Co., 3301 Monroe Street, plans installation of electric power equipment in new one and two-story addition, 116x162 ft., to cellophane container manufacturing plant. Superstructure will begin soon. Entire project will cost about $75,000. George S. Rider Co., Marshall Building, is architect and engineer.

Ohio, Columbus—Isaly Dairy Co., North High Street, plans installation of electric power equipment in new two-story and basement dairy products plant, 88x125 ft., in vicinity of North High and Olentangy Streets. Entire project will cost about $150,000. Richard, McCarty & Bulford, 584 East Broad Street, are architects.

Ohio, Hamilton—Beckett Paper Co., Hamilton, has rejected bids recently received for new steam power plant for mill service and will have revised plans drawn at once. Proposed to ask new bids soon. Installation will include a high-pressure boiler unit. Entire plant will cost over $200,000. Fosdick & Hilmer, Union Trust Building, Cincinnati, Ohio, are consulting engineers.

Ohio, Troy—Braun Brothers Packing Co., meat packer, plans installation of power equipment, refrigerating machinery and other mechanical equipment in new two-story addition to plant. Entire project will cost about $70,000. Lloyd J. Zeller, Tecumseh Building, Springfield, Ohio, is architect.

Ohio, Youngstown — Republic Steel Corporation, Republic Building, Cleveland, Ohio, plans installation of electric power equipment in connection with extensions and improvements in steel mill at Youngstown. Entire project will cost about $450,000. Company engineering department is in charge.

Ont., Toronto—Lever Brothers, Inc., Montreal, Que., a Canadian subsidiary of Lever Brothers Co., 164 Broadway, Cambridge, Mass., plans installation of electric power equipment in new multi-story addition to soap-manufacturing plant at Toronto. Cost about $1,000,000. Ewart, Armer & Byam, Toronto, are architects and engineers.

Pa., Erie — Hammermill Paper Co., Erie, has plans under way for new steam-electric power plant for service at paper mills. Cost estimated over $300,000. Stone & Webster Engineering Corporation, 49 Federal Street, Boston, Mass., is consulting engineer.

Pa., Meadville — Viscose Co., 200 Madison Avenue, New York, N. Y., plans installation of electric power equipment in new addition to acetate rayon mill. Entire project will cost close to $1,000,000. H. H. Bitler is superintendent at plant.

Pa., Pittsburgh — Bureau of Water, City-County Building, has plans under way for extensions in Ross Pumping Station for municipal waterworks, including equipment replacements. Installation will include a new 600-hp. boiler unit with accessories, pumping machinery and auxiliary equipment. Cost estimated at $135,000. Appropriation is being arranged.

Texas, Houston—Champion Paper & Fibre Co., Hamilton, Ohio, plans installation of electric power equipment in new multi-unit pulp mill on large tract of land on Houston ship channel, recently acquired. A power house will be built. Entire project will cost about $3,000,000. W. R. Crute, chief engineer at branch mill of company at Canton, N. C., operated as the Champion Fibre Co., will be in charge of construction.

Texas, Liberty — City Council will take bids early in March for new municipal electric light and power plant, for which financing in amount of $95,000 has been arranged through Federal aid. Installation will include three 150-kw. generating units and auxiliary equipment. Garrett Engineering Co., Houston, Texas, is consulting engineer.

Texas, Yorktown—Common Council has plans nearing completion and will take bids early in March for new municipal electric light and power plant, and electrical distribution system. A fund of $100,000 has been secured through Federal aid. Garrett Engineering Co., Houston, Tex., is consulting engineer.

Wis., Campbellsport — Stella Cheese Co., is considering construction of Diesel engine-generating station for service at plant. Estimates of cost are being made. Ralph W. Richardson, New York Building, St. Paul, Minn., is consulting engineer.